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A Review Of The Retention Problem

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Introduction

Much has been written and stated concerning the retention of corrected malocclusions of the teeth. Considerable difference of opinion has been evident in the writings of innumerable authors. An attempt will be made here to review and to criticize some of these opinions.

In searching through the literature on the subject of retention one of the most interesting sidelights concerns the suggestions of various authors as to the length of time that retainers should be worn. Everything from *no* retention whatsoever to retention *permanently* is suggested. On the other hand, some authors simply ignore the question of retention and make no mention of the amount of time that retainers should be worn.

Let me for a moment enumerate some of the factors that allegedly should determine the type and length of retention: The number of teeth moved, the distance that these teeth have been moved, the occlusion, the age of the individual, the cause of the malposition, the rapidity of correction, the degree of rotations corrected, the length of the cusps, and the health of tissues. We should be concerned with (a) the inclined planes (b) the size of arch or arch harmony (c) muscular pressure (d) approximal contact (e) cell metabolism and (f) atmospheric pressure. It is suggested that slight movement is more difficult to retain than extensive movement, that elastics should be worn continuously as a part of retention, that retention should depend on a fixed type of appliance, that satisfactory retention is dependent upon modification of structure and function of tissues, that occipital retention be used, that we should correlate treatment with development, that function is the most important factor in retention, that the appliances should be removable and not dependent on teeth for retention, that overcorrection of all malpositions should be attempted, that retention is dependent on bone changes which in turn are related to endocrine dysfunction, functional adaptation of occlusion and inherent growth, that retention is a problem of the apical base or apical base limitations, that mandibular incisors should be upright over basal bone, that possibly there are discrepancies in tooth sizes that cause problems in retention, that early treatment is more desirable than later treatment, that intercanine and intermolar widths should be maintained, that it is desirable to attempt functional treatment, i.e., to achieve muscle balance, that it is desirable to use mild forces, that there are limitations to moving teeth and that there are limitations imposed on the orthodontist by the arch size itself. These are only a few of the factors that have been mentioned by two or more authors.

In relation to *time* we can note the opinions of several authors. For instance, Kingsley[27] suggested that two or three years was a *long* period of retention; Guilford[22] suggested that re-

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tention should be maintained for not less than six months, and possibly in adults a year or longer; Talbot[55] devoted but two pages of his entire book to retention with no suggestion regarding time; Victor Hugo Jackson[26] suggested leaving the retainers off for a period of from three to five days and then checking the occlusion. If it was satisfactory then the retainer was to be removed from ten to twelve days at a time, or to be worn only at night. Pullen[48] suggested indefinite elastic wear to hold corrected Class II or Class III relationships. An interesting quote from Ottolengui,[46] "that for girls they wear it (retainer) until they get married." B. E. Lischer[32] suggested three weeks to seven years, or even *permanent* retention in certain cases. Case[12] describes in his book (1921) intermaxillary retention and occipital retention. McCoy[37] says that mechanical support for an undetermined period is necessary. Hellman[24] says in summary, "We are in almost complete ignorance of the specific factors causing relapses and failures." Hawley[25] said in 1919, "If anyone would take my cases when they are finished, retain them and be responsible for them afterward, I would gladly give them half the fee."

If one reviews the history of modern orthodontics he will find that present concepts of retention are probably derived from four schools of thought. As far back as 1880 Norman Kingsley[27] dwelt upon the undesirability and evil of retaining appliances and suggested that they be avoided as much as possible. Kingsley stated, "The *occlusion* of the teeth is the most potent factor in determining the stability in a new position." In this statement the essence of the first school of thought is contained. S. H. Guilford,[22] Eugene S. Talbot,[55] Victor Hugo Jackson,[26] Herbert Pullen,[48] Henry A. Baker,[3] Ottolengui,[46] Edward H. Angle,[1] Martin Dewey,[14,15,16] B. E. Lischer,[32] C. A. Hawley,[23] Calvin Case,[11,12] George Northcroft,[43] James D. McCoy,[37,38] Matt Federspiel,[19] Harold Chapman,[13] Paul Simon,[51] John B. Mershon,[39] Salzmann,[49] Marcus,[34,35] and Hellman[24] all considered that proper occlusion was of prime importance in the retention of treated orthodontic cases. An interesting quotation might also be included here from Oppenheim,[45] "Retention is the most difficult problem in orthodontia; *in fact, it is the problem.*"

In the middle 1920's a second school of thought formed around the writings of Axel Lundstrom.[33] From the era of Lundstrom to the present the apical base has come to be regarded as one of the most important items in relation to the correction and maintenance of a corrected case of malocclusion. Dallas McCauley[36] indicated that the intercanine width and intermolar width should be maintained as originally presented. This type of thinking was further emphasized by Strang.[52,53,54] Probably one of the most thorough and complete examinations of the problems of the apical base was done by Hays Nance[40] in 1947. In summarizing, Nance stated the following, "1) If a stable permanent result is to be attained in orthodontic treatment, mandibular teeth must be positioned properly in relation to basal bone. 2) Arch length may be permanently increased only to a limited extent. 3) Excessive lingual tipping of the mandibular incisors is to be deplored almost as much as excessive labial tipping of these teeth. 4) The proper positioning of mandibular anterior teeth demands careful case analysis. 5) Many failures are due to the orthodontist's failure in treatment."

Grieve[21] and Tweed[56,57] followed with opinions that the incisors must be upright and over basal bone. Numerous

authors since the writings of Grieve and Tweed have followed with like opinions, including Strang,[53] Salzmann[49] and recently Lindquist.[31]

Paul Rogers[73] introduced a school of thought which included the necessity of establishing proper functional muscle balance. This type of thinking has been followed by Dewey,[14,15,16,17] McCoy,[37,38] Ray Webster[59] and more recently by Allan Brodie.[8,9,10]

In summary, from the review of the literature, we find that orthodontists have come to realize that retention is not an item apart from treatment, but that it is a part of treatment itself and must be included in our treatment planning. As Hellman[24] so aptly put it, "Retention is not a separate problem in orthodontia, but is a continuance of what we are doing during treatment. It is not a definite stage in treatment requiring a new technique; therefore, there is no need for a separate machinery to carry it through. Retention is but a letting off of what we have been doing during treatment. The changes that we do make in our machinery are to ease up on the strains and stresses and to wean the tissues away from the effects of all of our tinkering so that any change that is made should be a reduction in appliance. This can be done by changing either the type of the appliance or the amount of time wearing it. *A complete result must be accomplished before retention is applied.*"

Discussion

We realize that stability of the end result is one of the prime objectives of orthodontic treatment for without stability neither proper function nor the best in esthetics can be maintained. Our realization must be then that retention probably is a problem of treatment dependent upon the occlusion established, that the occlusion established must be within the bounds of normal muscle balance and that occlusion and muscle balance established are dependent upon the amount of apical base available and the relationship of apical bases to one another.

From the review of the literature several interesting laws or rules may be derived. The following is an attempt to enumerate and to evaluate some of these so-called rules.

Rule 1. Teeth which have been moved in or through bone by orthodontic appliances often have a tendency to return to their former positions, therefore, certain cases do require retention.

There is but little disagreement with this rule. In recent times only George Englert of Danville, Illinois has been so brash as to suggest that retention is routinely unnecessary. Earlier, John Mershon[39] suggested that retention was unnecessary, but he must have been discounting the lingual arch as a retaining appliance for he suggested that it be kept in the mouth over long periods of time. Tweed[56,57] suggests that retainers should be continued for at least five years in most instances. The question of why teeth have a tendency to return to their former positions has, to this date, no real answer.

Rule 2. Arch form, particularly in the mandibular arch, cannot be permanently altered by appliance therapy, therefore, treatment should be aimed at maintaining, in most instances, the arch form presented by the original malocclusion.

The evidence brought to our attention first and foremost by Nance that attempts to alter arch form in the human dentition generally met with failure has been accepted realistically by most orthodontists. Studies of treated orthodontic cases out of retention have lent credence to this type of thinking.

In 1944, McCauley[36] made the following statement, "Since these two mandibular dimensions, molar width and cuspid width, are of such an uncompromising nature, one might establish them as fixed quantities and build the arches around them." Strang[52] said essentially the same thing as follows, "Therefore, I am firmly convinced that the axiom of the mandibular canine width which may be stated as follows: 'the width as measured across from one canine to the other in the mandibular denture is an accurate index to the muscular balance inherent to the individual and dictates the limits of the denture expansion in this area of treatment,' is the most important objective to maintain in treatment if one is to gain stability in the finished result."

In 1950, casts of twenty-two patients treated by the late Doctor Milton Fisher of Tacoma, Washington, became available to the orthodontic department of the University of Washington. In a thesis by Dona,[18] a former student in the department, the following information from cases out of retention was derived: In all instances, mandibular canine width, whether increased or maintained at the original dimension, returned to or maintained the original intercanine width after all retaining appliances had been removed for several years.

Two other examples of cases out of retention have been made available to me in the past few years. At the 1955 meeting of this society, held in Victoria, B. C., members were asked to send in cases that had been out of retention for five years or longer. About a dozen cases were collected that had reasonably complete records. In no instance was there any exception to the rule that mandibular canine width returned to its original dimension.

Several years ago I was able to make an examination of eight nonextraction cases and five extraction cases, treated by Tweed, which were out of retention for several years. Intercanine width was measured both at the widest point of the gingival margin of the mandibular canine and at the tip of the cusp of the mandibular canines, and from the mesiolingual cusp to the mesiolingual cusp of the mandibular molars. In the *nonextraction* cases an average of +.9 of a millimeter of expansion in the mandibular canines at the gingival margin was maintained after retaining appliances had been removed. At the height of the cusp a mean of +.8 of a millimeter of intercanine expansion was maintained and in the molar area +1.3 millimeters of expansion appeared to be maintained. In the *extraction* cases at the gingival area of the canines an average of +1 millimeter of expansion of intercanine width was maintained; at the height of the cusp a mean of +.18 millimeters of expansion was maintained and in the molar area a narrowing of —.4 of a millimeter was noted. In one case, three millimeters of intercanine expansion was produced and apparently retained successfully; this was a Class II, Division 2 nonextraction case which had been out of retention for two years. Several instances of three or more millimeters of expansion of intercanine width were found, but in these instances the mandibular canines had been considerably constricted and were blocked lingually to the general outline form in the mandibular arch. Certainly there are exceptions to the rule of inviolability of mandibular arch form and intercanine width, but we cannot expect all of our patients to be exceptions. Extraction of two mandibular incisors sometimes satisfies the requirements of arch form without intercanine expansion (with removal of two maxillary bicuspids).

Rule 3. The elimination of the causes of a malocclusion should certainly aid in the retention of its correction. Therefore, a proper diagnosis based on determining the cause of the malocclusion is invaluable.

When obvious habits such as thumb sucking, lip biting or tongue thrusting are the causes of a particular type of malocclusion, then little difficulty is presented in the diagnosis of the determining cause. Unfortunately, many of our malocclusions appear with apparently unknown origins or at least origins about which we can do little. Certainly heredity plays a most important part in determining the presence of many malocclusions. It has been suggested by various authors that approximately twenty-five to twenty-eight per cent of malocclusions are on a local basis, i.e., that they are preventable, such factors as prolonged retention of deciduous teeth, early loss, etc. Perhaps two per cent are congenital in origin such as cleft lip, cleft palate and so on. The other seventy per cent are hereditary in origin, based on racial admixtures and perhaps the gradual recession of the face beneath the cranium. From observation it seems apparent that individuals inherit Class II or Class III malocclusions. Crowding and spacing can probably be attributed to genetic factors.

Until more is known about the causative factors that are related to a particular type or types of malocclusion, little can be done about the elimination of these causes.

Rule 4. Overcorrection of a malocclusion is a safety factor in retention. Therefore, it is well to overcorrect the various malpositions and malrelations of teeth and jaws.

This rule has yet to be put to the test. Overcorrection of severe overbite seems to be an accepted procedure in many offices. Overcorrection of openbite cases by the establishment of a deep overbite has been seen by the author. Certainly there are many instances recorded of cases of overcorrection of Class II and Class III relationships. One of the most irritating types of relapse is the tendency for a previously rotated tooth to rotate towards its former position. It is all very well to talk about overrotation, but how many orthodontists actually perform it and to what degree. Little evidence is available to show that overrotation has been carried out and there is even less evidence to indicate that such overrotation is successful in preventing the return to the former position.

At this point the old axiom of "an ounce of prevention is worth a pound of cure" might well be inserted. Very often in the case of mandibular and maxillary anterior teeth, it would have been possible to prevent teeth from erupting in a rotated position by providing more space for them. Such space can be provided either by orthodontic appliances or by the early extraction of deciduous teeth.

Rule 5. Occlusion is an important factor in retention; therefore, an orthodontist should attempt to produce the best possible occlusion of the teeth.

The influence of occlusion is a factor in retention which has often been mentioned and certainly the best possible occlusion is a factor in the retention of corrected malocclusions. Whether or not it is *the* most important factor is certainly debatable. In too many instances we have seen teeth, even with high cusps, locked into normal occlusion that will still tend to return to their former positions. It is evident that many orthodontists consider the denture from a static viewpoint, i.e., with the teeth in occlusion. The functional relationships of teeth are certainly important factors in retention and this has been recently emphasized by

numerous authors directing our efforts toward proper occlusal equilibration. From the standpoint of reducing the potential of irritations to the periodontium, an excellent functional occlusion is certainly to be desired.

Typically, orthodontists blame overfunction or pounding of the mandibular canines by the maxillary canines as a cause of relapse in the mandibular anterior area. I doubt that hyperfunction or overfunction has very much to do with relapses of orthodontic cases. No less an authority than Sicher[50] agrees with me in this regard. The everyday evidence presented by the tremendous wear that many teeth undergo would indicate that they do not move in response to repeated grinding and tapping until bone has either been so thoroughly destroyed that it allows their migration, or until fibrous tissue builds up to a degree where it actually moves the teeth and function on these teeth is actually not possible. I have seen instances of mandibular anterior collapse where the canines have either not yet erupted or are not actually in occlusion. No doubt, we can say that a perfectly normal denture functions best.

Rule 6. Bone and adjacent tissues must be allowed to reorganize around the newly positioned teeth for some length of time, hence some type of retaining appliance should be used either fixed and rigid or only inhibitory in nature and not dependent upon the teeth.

Histological evidence has been presented which would indicate that both bone and tissue around teeth which have been moved by orthodontic appliances are altered and that considerable time must elapse before complete reorganization occurs. Some authors have indicated that retainers should be fixed and rigid such as Angle,[1] who suggested "G" wire, band and spur type attachments, bands soldered together, etc. Others have indicated that retainers should only be inhibitory and have no positive fixation to allow for the natural functioning of teeth. It has been suggested that the mandibular lingual arch admirably suits this description. Oppenheim[45] suggests that appliances should be only inhibitory in nature and that repair of tissues around the teeth occurs much more rapidly if no fixed type of retaining appliance is used. If time must elapse to allow repair to occur, then, in relation to removing retaining appliances, we might resort to the old railroad axiom, "When in doubt, proceed with caution. Speed must be sacrificed for safety."

Rule 7. Placing the lower incisors upright over basal bone will result in a more stable correction of a malocclusion. Therefore, our attention should be directed toward the proper angulation of the mandibular incisors.

The difficulty of evaluating this contention revolves around *proof* of the fact that incisors have been placed upright over basal bone. We have been able to define fairly well what *upright* means, possibly a plus or minus five degrees from mandibular plane, or a relation to occlusal plane, or Frankfort horizontal. As to what is *basal bone*, there is no experimental evidence to indicate that anyone can specify where this bone begins or ends. There seems to be no accurate method of measuring basal bone. I do believe many practitioners assume that teeth that are upright are suddenly over basal bone. Instances have been recorded where the roots of mandibular incisors have actually been moved labially to a considerable degree in the process of uprighting these teeth. Within the past several years Tweed has recognized this fact and has included in his mandibular arches slight lingual root torque to prevent throwing the roots

of mandibular incisors labially. We have all seen cases where the mandibular incisors are upright and as over basal bone as we could hope to have them, yet these teeth were both crowded and rotated. Hence teeth that have the very attributes of stability are in a state of malocclusion.

From a purely mechanical standpoint, there is a certain amount of virtue in inclining the mandibular incisors slightly to the lingual. Those of you who have set mandibular anterior teeth in wax will note that, if they are aligned with a labial inclination, attempts to push them lingually must result in expansion in the canine area or the collapse of these anterior teeth. On the other hand, if the anterior teeth are inclined lingually, further pressure to the lingual does not cause collapse and certainly tipping to the labial will only create spacing. Hence, if we are to make any errors in positioning our mandibular incisor teeth, it is probably well to err in the direction of a lingual rather than a labial inclination.

Rule 8. Corrections carried out during periods when the patients are growing are less likely to relapse, therefore, orthodontic treatment should be instituted at the earliest possible age.

There seems to be little *positive* evidence to substantiate this statement; however, it has a good deal in its favor from a logical standpoint if orthodontists are in any way able to influence the growth and development of the maxilla and/or mandible. It is certainly logical to presume that the growth of maxilla or mandible can only be influenced while the individual is growing and that once growth has been completed this potential is no longer available. As Matt Federspiel[19] said as far back as 1920, "It is impossible to correct a Class II, Division 1 malocclusion without the extraction of bicuspids if the individual has completed his or her growth."

Much has been said about the change in muscular balance established by changing the positions of teeth which in turn will promote rather than retard normal growth. Whether malrelations in muscle balance have as much influence on growth and development as has been supposed is very difficult to say. A certain amount of theorizing can be done about correcting rotations before root formation is fully completed. We can say here, however, that where treatment depends on a retardation or change of direction of growth such as is effected in headgear therapy, treatment must be instituted during a period of growth.

Rule 9. The farther teeth have been moved the less the likelihood of relapse. Therefore, cases in which it has been necessary to move teeth a great distance are in need of lesser retentive attention or it is desirable to move teeth farther in the process of orthodontic treatment.

The wisdom of this rule has really not yet been put to the test; however, from a logical standpoint, teeth which are far removed from their previous environment might reasonably be expected to have less tendency to relapse than those that are near their former environment. Here we may speculate on some of the so-called bimaxillary protrusions produced during orthodontic treatment which have not shown a tendency to relapse in spite of the fact that there is a pronounced labial axial inclination of both maxillary and mandibular incisor teeth. It might well be that in some of these cases the teeth are moved far enough to be outside of the influence of labial musculature. Actually there is little real evidence to support the statement that the farther teeth have been moved the less relapse tendency they will have.

Of these rules the following seem

to be the most important: teeth do tend to move back toward their former position; the arch form of the mandibular arch cannot be permanently altered by appliance therapy; bone and adjacent tissues probably should be allowed time to reorganize around newly positioned teeth and early corrections are less likely to relapse.

At this point we can be certain that orthodontic case analysis has come to include a plan for retention, not as a separate posttreatment period demanding different or unusual appliances, but rather as a part of active treatment inseparable, dependent and intimately associated with the changes brought about during treatment. However, there are several other important factors mentioned but not elaborated upon in the literature which do have an influence on the retention of treated malocclusions.

Tooth-size discrepancies

Though discrepancies in tooth size have been mentioned by Ballard as existing in up to ninety per cent of the individual casts of five hundred patients whom he examined and although Neff[41] arrived at an "anterior coefficient" by dividing mandibular into maxillary anterior tooth size, little has been done until recently to provide a useful workable method of determining tooth-size discrepancies. Bolton,[7] at the University of Washington, using fifty-five cases of excellent occlusion, determined that a certain percentage relationship must exist if a normal occlusion is to be established.

It has long since been evident to the prosthodontist that if the maxillary anterior teeth are too large for the mandibular, the maxillary teeth must be placed in one of several positions: (a) in a deeper overbite, (b) in a position of greater overjet, (c) combination of greater overbite and overjet or, (d) the buccal segment posterior to the canine not be allowed to occlude properly, the maxillary posterior teeth fitting into a more or less distal relationship to the mandibular.

There are instances where the mandibular anterior teeth may be too large for the maxillary. The result can only be: (a) an end to end relationship of the maxillary and mandibular incisors, (b) spacing in the maxillary anterior teeth or, (c) improper relationship distal to and including the maxillary canine with the maxillary posterior teeth in a mesial relationship to the mandibular posterior teeth. It is possible to estimate and determine these discrepancies by making a trial setup. However, it can be determined beforehand by mathematical means whether such a setup is necessary and almost the exact amount of tooth-size discrepancy existent.

Axial Inclinations

A factor which has been overlooked in the retention of corrected malocclusions is the axial inclination of the maxillary incisor teeth. In many instances we are brought to the realization that the farther back our mandibular incisors have been carried the farther must our maxillary incisors be retracted. Maxillary and mandibular incisors that are tipped into too upright a relationship to one another usually lead to a deep anterior overbite. Our periodontist friends can tell us much about the functional implications of deep overbite in the incisor area. It is interesting to note that Bolton found the angles of the labial surfaces of the maxillary and mandibular central incisors to their occlusal plane totalled 177°. In other words, the labial surfaces of the maxillary and mandibular incisors in profile formed almost a straight line.

Functional Interferences

It is the author's opinion that functional interference as a cause of relapse in treated orthodontic cases has been overemphasized. Many collapses in the mandibular incisor and canine area have been attributed to functional interferences and yet examination of some of these cases simply shows evidence of excessive intercanine expansion. Fischer,[20] in an article in 1943, and Strang[52] in 1952, both illustrate such cases blaming canine overfunction. In their illustrations measurements of intercanine width indicate the canines had been expanded and collapsed back to their original dimension. Further proof in this direction is evident in cases where the mandibular incisors and canines collapsed, yet maxillary canines and incisors were not in occlusion at all. Hyperfunction or complete lack of function are probably most undesirable from the standpoint of normal tissue and bone health, but teeth do not seem to move in response to hyperfunction unless considerable loss of bony support or root length has occurred. Simple evidence of this fact is seen in the tremendous amount of wear that many teeth will undergo without any indication of a change in position.

Growth and Sex Differences

Growth may be an aid in the correction of many types of orthodontic problems and it also may be of such character as to cause a relapse of treated orthodontic cases. We probably take advantage of growth in individuals treated in the mixed dentition with cervical anchorage preparation. Cephalometric records indicate that we influence the normal downward and forward growth of the maxillary alveolar process and it is possible that the growth of the maxilla itself may be retarded. While the normal forward movement of the maxillary molars has been restrained, the mandible continues in its normal course of growth.

We find essentially the same type of thing mentioned above occurring in treatment of all types of Class II cases, i.e., that the maxillary buccal segments are not so much moved bodily distally (although the maxillary buccal segments may be tipped distally and there is some difference of opinion as to whether this is a desirable position for these teeth to assume), but that our correction takes place as a result of mandibular growth and/or forward translation of mandibular teeth.

At this point it might be well to discuss the so-called "Tweed Response." I quote the conclusion of a thesis by Knell[29] in which he compared a group of patients treated by Tweed with a similar group treated at the University of Washington. The Washington group was not treated to Tweed standards or by his methodology. "Changes in the forward positioning of the chin were unpredictable and varied greatly in each group. There was no conclusive evidence which would indicate that Tweed was able to produce a greater forward positioning of the chin through his treatment technique. The females treated by Tweed showed the same mean net change for the forward positioning of the chin as University of Washington females. There was a greater retraction of the maxillary apical base in the cases treated by Tweed, retraction of the mandibular apical base was less than that of the maxillary apical base, and this change showed a trend for greater retraction in the cases treated by Tweed. The greatest significant difference between the two groups involved linear and angular reductions in the protrusion of the lower incisors."

A recent study by Bash[5] comparing

soft tissue outlines only of Class II, Division 1 malocclusions treated by Tweed and at the University of Washington would indicate significantly greater retraction of the soft tissue of the upper lip in the Tweed cases.

At the same time that we discuss growth we must be aware of the fact that the sex of the individual patient is an important factor to be considered when planning treatment and retention. Figures derived by Baum,[6] Petraitis[47] and Baird[2] from individuals possessing excellent occlusion would indicate that there is a marked difference between the maturation of skeletal and dental patterns of male and female. An analysis of the skeletal and dental patterns of females age eleven to thirteen establishes that they are not significantly different from the patterns of adult females. On the basis of these and several other investigations we may conclude that on the average the female skeletal and dental pattern matures before the thirteenth year, whereas, in the male, skeletal and dental patterns mature somewhere after the fifteenth year. The significance of this knowledge is important in relation to the female Class II, Division 1, if we are to take advantage of mandibular growth in the restraint of the maxillary arch. Certainly we must start our treatment at some time prior to the maturation of skeletal and dental patterns.

Further Implications of Growth

The implications of continued mandibular growth are so well known regarding true Class III malocclusions that few orthodontists attempt to complete orthodontic treatment and/or surgery until the individual has ceased to grow. However, there are other growth peculiarities which are of importance to the orthodontist. Maturational changes can and do occur, particularly in the male, in relation to the apical bases and alveolar processes. There occurs in some individuals a so-called swing of the facial structures out from beneath the cranium in the maturation period. This swing may take the effect of reducing the angle of convexity, reducing the differences in apical base relationships and increasing the angulation of maxillary and mandibular incisors to one another. A restriction of the mandibular denture may be produced. In the process of the incisors uprighting the buccal segments may tend toward a Class III relationship. The occlusal plane flattens, the mandibular plane flattens, and oftentimes overbite is reduced. Several authors have demonstrated that during growth the permanent dentition has a natural tendency to become more recessive in relation to the body of the maxilla and mandible, and that, particularly in the male, we can expect to find the mandibular denture more posterior in relation to pogonion.

The purport of these findings brings up several considerations in relation to orthodontic treatment. For instance, we may consider postponing treatment to a somewhat later developmental period in the male as compared to the female; or, to put it in another way, treatment should be begun earlier in the female, particularly in the Class II type. Another implication involves the continued retention, particularly in the male, of the maxillary and mandibular incisor areas. In our office it is a routine practice to attempt to retain the mandibular anterior segment in males until we are fairly sure that they have completed their total skeletal growth.

The use of occipital anchorage (Kloehn,[28] Lewis[30]) in retention is based at least in part on the expectation of restraining further maxillary growth and, of course, allowing more mandibular development.

Recovery from Individual Tooth Movements

In the past a certain amount of work has been done by research workers using cephalometric techniques in the direction of establishing the limitations of orthodontic treatment. For instance, it has been well known for many years that changes induced by treatment in the inclination of the mandibular plane are probably not permanent unless they are in a negative direction, i.e., that the mandibular plane angle as related to Frankfort or SN tends to flatten with age. The implication is this: if it is noted at the completion of orthodontic treatment that the mandibular plane angle has increased, it can be expected to return to its former angulation or less. If no further growth is forthcoming in the individual, the return of the mandibular plane angle to its previous inclination will probably involve an increase in overbite. If, on the other hand, further growth is forthcoming and maxillary and mandibular teeth are retained in a position of minimum overbite, we may expect a greater increase in posterior face height and levelling of the mandibular plane without increase in overbite. The occlusal plane probably cannot be permanently altered except in a negative direction (to SN or F.H.). Hence, recent treatment techniques, such as proposed by Tweed and elaborated by Holdaway,[25] attempt first to tip the occlusal plane down posteriorly with Class III mechanics as a preparation for the later tipping up in back and down anteriorly that will occur with Class II elastics. If, in the individual case, no further growth is forthcoming and the occlusal plane has been tipped up in back, the subsequent change of the occlusal plane angle may mean an end to end relationship in the posterior segments and/or deepened overbite of the anterior teeth. If, however, mandibular posterior teeth have been previously tipped distally they may recover in a mesial direction, thereby maintaining a Class I relationship with the maxillary posterior teeth, providing that the maxillary posterior teeth do not tip forward an equal or greater distance.

Further implications that may be derived from growth studies involve changes that will probably occur particularly in the faces of males in the apical base relationships. For instance, what we record as an angle of convexity of twelve degrees in a boy age nine may some day be an angle of convexity of only three degrees in the mature male, or perhaps even less; hence, in attempting to relate incisors both in inclination and bodily position by means of a standard such as the angle ANB or angle of convexity, we must be aware of the possibilities of future growth changes in these relationships and aware further of the results that may be produced by orthodontic treatment as well. We must be aware that the normal mandibular denture is carried upward and backward away from pogonion and that probably bony addition occurs at pogonion itself so that the relationship of mandibular incisor teeth to pogonion at ages nine to twelve is certainly not to be regarded as a permanent position for these teeth.

I do believe that we have seen the pendulum swing in the direction of too much incisor retraction, both mandibular and maxillary, because extraction is handled quite lightly. It has been stated and implied that the careless operator can very easily lose mandibular and maxillary anchorage. It is true that we have seen in a number of instances the injudicious application of mechanics to a point where extraction spaces have been closed primarily by mesial movement of the posterior

teeth, particularly in cases in which considerable crowding was present. Conversely, there are a number of instances where, with a minimum amount of crowding, the orthodontist has found it difficult, if not impossible, to prevent retraction of the mandibular and, consequently, maxillary anterior teeth. In instances where I have attempted to maintain mandibular incisor teeth in their original anteroposterior position and extraction was a part of treatment therapy, I have been all too often discouraged to see the mandibular anterior teeth move lingually, in spite of all my attempts to maintain them.

A certain amount of misinformation is available regarding the attempts of teeth to recover their former inclinations after orthodontic treatment and retention. It has been implied that the esthetic benefits of orthodontic treatment were lost particularly in the treatment of double protrusions by these relapse tendencies. We have been given certain rules by Holdaway[25] as to the recovery of the maxillary and mandibular permanent molars. Holdaway suggests that during treatment the maxillary first permanent molar is tipped distally with the apex as a pivotal point and that it recovers again by tipping mesially with the apex again as a pivotal point. Wallman,[58] at the University of Washington, examined thirty-seven patients treated by Tweed. Lateral headfilms before treatment, after treatment and at least a year and a half to three or four years after the discontinuation of appliances were used in this analysis. He found a variety of changes in the recovery of moved maxillary molars. These molars tipped mesially after treatment, moved bodily mesially at the same time, moved only bodily mesially, continued to tip distally, continued to move bodily distally, and in short, showed a range of movement that covered most of the possible movements that one could expect. Wallman did find that the maxillary permanent molars were the least variable of all the teeth in their recovery attempts, and that eighty-three per cent of all of the changes in the recovered maxillary molar fell in the two categories. In nineteen instances the crown moved forward and the root moved back. In eleven cases the crown moved forward and the root moved forward, usually the crown more than the root. In only three occurrences did the crown tip forward with the apex at the root as a pivotal point. One thing did become clear, however; in most instances there was little bodily distal movement of the maxillary permanent molars.

We have also been told in relation to the mandibular posterior teeth that once the crown is tipped distally and the roots tipped mesially during orthodontic treatment, that the tooth tends to recover with a pivotal point in the area of the gingival margin, i.e., that the crown tips mesially and the root tips distally. There was no typical recovery of the mandibular first permanent molar. In ten cases the crown did move anteriorly and the root posteriorly, although not necessarily in equal amounts.

In seven examples the crown and the root moved posteriorly, usually with the root moving posteriorly more than the crown. In four instances the crown and the root moved anteriorly, usually with the crown more than the root. In four cases the crown alone moved anteriorly. These movements account for only twenty-five of the thirty-seven cases studied. No hard and fast rules could be laid down about the recovery of mandibular permanent molars from the effects of orthodontic treatment.

When we obscure the facts of ortho-

dontic treatment with the maturational changes that occur, the difficulties of examining recoveries from orthodontic treatment become apparent.

One common characteristic was found concerning the maxillary and mandibular incisors in their recovery from orthodontic treatment. If these teeth had been depressed during treatment, typically they tended to erupt again after treatment is discontinued. There were no other typical movements in the recovery of moved incisors with the possible exception of the fact that in eighty-nine per cent of the cases the maxillary incisor moved forward after treatment. In twelve instances the crown and root moved anteriorly with the crown moving more than the root; in six cases the root more than the crown, both root and crown moving anteriorly. In six examples there was equal anterior movement of root and crown. Five times the crown alone moved anteriorly. The mandibular incisor was even less regular in its recovery pattern, sometimes tipping labially, sometimes lingually or moving bodily in either direction, or combining bodily movement and tipping movements either labially or lingually. Rarely did the maxillary anterior teeth continue in a lingual direction, either tipping or bodily, in recovering from orthodontic treatment.

Another interpretation that may be derived from studies of treated orthodontic cases is that speed may not necessarily be most desirable in treatment. Since growth occurs in relation to time, there may be instances where continued orthodontic treatment may take advantage of growth if we are at all able to restrain maxillary growth and/or stimulate mandibular growth. I do not find it distasteful, if after a period of Class II therapy I find my mandibular anchorage slipping, to resort to Class III elastics, for the time gained may well include continued growth and consequently a more stable correction.

Perhaps it would be well at this point to attempt to classify retention according to the requirements of various types of cases. For this purpose I have divided retention requirements into four categories:

Group I

Cases that require no retention in either arch.

A. The anterior crossbites, provided that a reasonable overbite has been established.

B. Posterior crossbites, after good interdigitation has been established and whenever the teeth have not been abnormally tipped in order to correct the crossbite. (An exception to this rule is found in teeth whose cusps are flat or nearly so, where a deep mechanical interlocking is not provided).

C. Some "high cuspid" extraction cases and some cases treated only by planned extraction therapy.

D. Cases in which maxillary or mandibular molars have been tipped distally or bicuspids tipped mesially to provide space for the eruption of second bicuspids. Once the second bicuspid has erupted no further retention is necessary.

E. Class II cases treated with headgear on the basis of restraint of growth. Once the growth period has passed no further problem of retention will be evident.

Group II

Cases in which it is necessary to continue permanent or semipermanent retention in one or both arches.

A. Instances where expansion has been carried out in one or both arches.

B. Class II or Class III relationships which have been corrected by creating a "dual bite." Muscular adaptation will allow the mandible to be positioned forward after strong Class II elastic therapy and the patient seemingly cannot retract the mandible any farther; yet if Class II therapy is discontinued, in a matter of several weeks the patient will again be able to retract his or her mandible farther posteriorly.

C. Severe rotations, particularly of the maxillary and mandibular anterior teeth and mandibular bicuspids (whether overrotation might lessen this problem of retention is not known).

D. Cases which initially had considerable spacing.

Group III

Cases requiring varying lengths of retention.

A. Class II cases, extraction or nonextraction, need no mandibular retention if therapy is well instituted provided that the original mandibular arch did not show any severe rotations and that there were no breaks in contact alignment other than in the vertical plane. Some of these cases whose maxillary anterior teeth have been retracted need some restraint for an undetermined period of time. Sometimes, if good muscle balance has been achieved, no retention is necessary. Hence, short periods of full time retention, then two or three months of retainers at night only and later every other night may be sufficient.

B. Cases having had deep overbites may require an indeterminate length of time in retention with the object of attaining the greatest possible vertical development in the buccal segments while the anterior teeth are held in a minimum amount of overbite. Certainly growth is an important factor in determining the permanency of result and the time of retention is directly dependent upon growth.

C. Class II, Division 2 cases require indeterminate periods of retention. In the Class II, Division 2 malocclusion possibly the response in adaptation of musculature has much to do with the stability of the treated result.

D. Class III corrections achieved with the assistance of surgery in shortening the mandible or setting it posteriorly by a variety of methods require varying lengths of retention.

E. Cases involving the ectopic eruption of teeth or where supernumeraries have been present require varying lengths of retention planning.

Retention is and will continue to be a problem of treatment.

U. of Washington

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Discussion

Dr. George Hahn

Because of the time limit this paper had to be read at a pace that did not give you time to absorb it or get its true worth. Fortunately the members of the panel had the opportunity of studying it several weeks in advance and I can truthfully say that it is the best paper I have ever read on the subject of retention. I think you will all agree when it is published and you have time to digest it at your leisure.

Years ago Dr. Angle stated that, "The object of retention was to antagonize the teeth in the direction of their tendencies". Think this over carefully and you will find that it is just about as well put as you would want to describe the requirements of retention of any type of corrected malocclusion.

In recent years so much attention and publicity has been given to newer methods and philosophies of diagnosis and treatment that the importance of retention in the case has been largely overlooked. A good axiom to follow is that if you cannot plan adequate retention for a case don't treat it. To many otherwise competent orthodontists retention means nothing more than "sticking in a couple of Hawleys".

Hays Nance is responsible for the statement that, "Many failures during and after the retention period are due to failures in treatment". The three most common causes of failures or relapses are:

1. lack of care in correcting rotations
2. developing dual bites through the excessive use of Class II elastics
3. incorrect arch form

Rotations: All rotations should be slightly overtreated to allow for the small amount of relapse that will generally take place even years after the retainers are removed. I realize that overcorrecting rotations, especially in the anterior region, detracts from the beautiful evenness of the finished result at the time the appliances are removed but you will find that after fifteen or twenty years overcorrection has been good insurance. Rotations can be nicely retained with a band and opposing spurs or by a band with a lingual extension that engages a slot in the acrylic plate. The latter is particularly effective in the control of rotations in bicuspids and molars.

Dual bites: Fifteen or twenty years ago before the value of extraoral anchorage was generally recognized, the most common cause of orthodontic failure was in the relapse of cases in which Class II intermaxillary force had been used extensively during active treatment. Most of us were the victims of wishful thinking that the upper teeth would move distally and the mandible would stay put even though we knew from our knowledge of the anatomy and physiology of the temporomandibular joint and of the mechanics of a rubber band stretched between two points that such a thing was highly improbable. If cases requiring distal movement of the upper teeth are treated exclusively with extraoral anchorage, there will be no chance of mandibular recession after treatment. Due to the

psychological effect on a child of wearing extraoral anchorage twenty-four hours a day, a compromise of fifteen hours of extraoral force and nine hours of light intraoral force primarily to hold what has been gained during the preceding fifteen hours proves to many to be a reasonable compromise in solving this particular problem of relapse during retention.

Arch form: I must take issue with the author on his statement that, "Arch form, particularly in the mandibular arch, cannot be permanently altered by appliance therapy". There are too many cases on record where such a change has been made and permanently maintained. The mistake that many of us make, and I believe it is the reason for our failures, is that over the years the average orthodontist develops an arch form that is pleasing to him and unconsciously builds that arch form into every archwire he bends irrespective of the physical type of the patient he is treating at the moment. This results in giving the patient a dental arch that is not in harmony or balance with his facial pattern or architecture and failure is certain.

Stability of periodontal bone is not possible with a fixed retainer. As an example, consider the ever popular cuspid-to-cuspid lingual bar commonly used where the cuspids have been subjected to mechanical rotation and the anterior teeth have been crowded. In this situation there is nothing at present as effective or as efficient retentionwise as this type of retainer. Yet it is a comparatively long span with little support except at each end and, when occlusal stress is applied on one cuspid, it reacts on the other. This results in a jiggling of both that inhibits the formation of stable periodontal bone. When used, it should be in conjunction with a lingual plate that should be worn for several months before the removal of the fixed retainer.

I cannot agree with Dr. Riedel that Angle advocated the use of fixed retainers save in those cases where there was no other way of providing adequate retention. In support of this I quote from the seventh and last edition of his book. One of the principles of retention is . . . "To give the teeth freedom of movement in every direction save that toward which they tend to return". This freedom of movement is not possible with a fixed retainer.

I am sincere in expressing my appreciation for the privilege of adding my bit to a truly excellent contribution to orthodontia.

Dr. R. H. W. Strang

No one can disagree that stability of the final result of treatment should be one of the most important factors for the orthodontist to take into consideration.

I heartily endorse Dr. Nance's statement that many failures to obtain stability are due to the orthodontist's failure in treatment.

For the past eleven years I have preached and taught that every case of malocclusion represents a denture in muscular balance. Hence if this status of muscular balance is preserved in treatment, a stable result will be obtained without mechanical retention.

It may be of interest to you to know what has been the answer to a long period of testing this firm conviction. I have followed the rule in treatment to maintain the width across the mandibular canines as the key to muscular balance. If the canines are moved distally in extraction cases, the width across the first premolars becomes the guide.

At the end of treatment the maxillary appliances are removed first. A so-called settling period of a few weeks intervenes before the mandibular appliances

are removed. The case is then kept under observation at three months' intervals subsequent to the removal of the mandibular appliances. Failure in stability has occurred in twenty-six per cent of these cases. Seventy-four per cent have maintained a satisfactory stabilization without mechanical support.

Reviewing the cases that have begun to relapse and were subsequently retained, the following conditions were in evidence.

(a) Rotation of maxillary incisors. In analyzing the cause for this I would present the following reason. I am a firm believer that the correction of rotated teeth should always be overdone by a combined turning of both mesial and distal portions of the teeth. Unfortunately, this cannot be accomplished in many of the maxillary incisors because the side of the tooth that must be overturned lingually rests against the mandibular incisors and this prohibits the excessive lingual movement. Hence the recurrence of the rotation of these teeth is apt to happen.

(b) Return of the overbite and overjet. If the patient has not harmonious vertical growth in the oral area before treatment is begun, stability in the corrected overbite cannot be hoped for.

(c) Patients with extreme hypertonic, boardlike muscles will reshape the corrected dental arches into a form that duplicates the original malocclusion.

(d) Patients with powerful muscular habits that the operator has been unable to correct will do likewise.

(e) Some extraction cases will have spaces recurring between the canines and second premolars. This, I believe, is due to the fact that too much tooth material has been removed. Unfortunately we cannot cut teeth into halves or thirds and leave the remainder in the mouth and thus avoid this spacing.

(f) Inharmony of tooth material in the two dentures which results in spacing in the maxillary denture or crowding in the mandibular incisors.

I feel certain that most of these cases, if they were mechanically retained for years, would, when released, relapse to the above described conditions.

Relative to rigid retention for a lengthy period versus freedom to settle under functional stress, it would seem that the latter is more advantageous to the restoration of strategic bone formation for stabilization than the former.

When we note the incisors in cases of malocclusion are far off basal bone and yet are well stabilized, one cannot help but ponder over the necessity of placing these teeth over basal bone in order to effect stability.

Personally I feel that muscular balance has more influence in effecting stabilization in our completed cases than any other factor. Dr. Riedel's division of retention requirements into four categories seems quite rational and most of its details agree with my clinical deductions.

Dr. Howard M. Lang

I can add but few remarks to those already so ably stated by Dr. Riedel and reiterated by Dr. Strang and Dr. Hahn concerning the retention problems of our orthodontically treated cases.

Retention should definitely be considered while planning our treatment procedures. We must strive to place the denture in balance with the bony structures and the muscle forces of mastication. Tooth discrepancies must be closely watched as they often affect tooth alignment and cause relapses. If necessary, tooth width of the case should be altered before treatment is

started as determined from a diagnostic setup, or measurements of tooth discrepancies as advocated by Carey, Neff and Bolton.

Proper diagnosis is most important. Before removing deciduous cuspids to let the anteriors assume a more esthetic relationship, make certain you are doing the right thing and not allowing mesial drift of the posterior segments. This could cause untold work to regain the space lost or end in extraction when it really wasn't indicated if a careful analysis had been made. Dewel has often stressed this point. A plan of caution is the wisest. Perhaps there is a wedging action of the erupting teeth causing expansion just as grass will crack the cement of a sidewalk in obtaining room to grow.

In closing, I wish to express my thanks to Dr. Riedel for again making us cognizant of retention and its closely allied relationship to treatment itself. If all of us would spend a little more time and effort in observing our cases under retention, we would learn more about this phase of treatment and I am sure as a result would improve active treatment procedures.

Dr. Allan G. Brodie

Reference has been made by both the essayist and the discusser to the generally accepted idea that it is necessary to adhere closely to the arch form presented by a malocclusion when we seek to treat it and when we retain it.

A number of years ago there was a study undertaken on this question and the results were published in the *Angle Orthodontist* for January, 1953. It was titled, *"Changes in Form and Dimensions of Dental Arches Resulting from Orthodontic Treatment,"* and was written by Douglas C. Walter. It has been completely ignored by both the essayist and discusser and indeed by almost everyone else because I have never seen it referred to. Yet it bears directly on the question we are discussing.

As a graduate student Dr. Walter asked whether it was true that a dental arch could neither be widened or lengthened by orthodontic treatment. I suggested that he try to find out for himself. This he proceeded to do in the following manner:

He selected a sample of one hundred and two cases, approximately half from each of the practices of two experienced orthodontists. On each there were available the models at the beginning of treatment and those made from one to thirteen years after all retention was removed. The average was two and one-half years. On somewhat less than half of the cases, models at the end of treatment were also available. In none of the cases had extraction been part of treatment.

Of the entire sample only two cases showed marked rotating or other slipping of contact at the postretention stage, eleven showed minor rotations or other indications of slipped contacts while eighty-nine of the one hundred and two cases showed no demonstrable relapse.

On this sample bilateral measurements were made between every pair of teeth of both arches and longitudinal measurements from the mesial contact of one of the first molars to that of the opposite side.

The findings revealed what anyone should expect when dealing with biological factors, viz., a wide variety of results. Many cases, expanded during treatment, returned to their pretreatment widths, or even beyond. Some cases showed no difference of width dimension at the end of treatment and in the postretention record. Cases were found in which considerable expansion had been gained and had held, and

there were those that had been expanded considerably during treatment and had continued to expand following the retention period. The same types of findings were made regarding gains in arch length. And it must be remembered that all of these cases had maintained the occlusal result gained in treatment; all but ten per cent were highly successful cases.

Throughout this entire discussion there has been, with one small exception, a total ignoring of the factor of growth. We are not dealing here with an unchanging machine, we are dealing with an organism and a very complex organism at that.

In the first place, we have a combination of variables of completely different types, teeth and bones. They differ in their origins, their mode of growth and in the manner in which they come into function. The teeth are formed to their complete size long before they erupt, which they do as complete units. A tooth cannot erupt as an eighth of a tooth or a quarter of a tooth. The jaws, like almost all other organs *gradually* increase in size.

Statistically speaking the teeth behave as discontinuous variables and their accommodation resembles the adding of cars to a train, i.e., a full car is added at a time. Jaw growth is a continuous variable, i.e., it proceeds from stage to stage by imperceptible degrees, as temperature is seen to rise in a thermometer.

If these two variables, eruption and jaw growth, are perfectly integrated we witness uneventful aligning of the teeth without crowding or spacing. But this does not happen in more than a certain percentage of the population. In some, eruption is ahead of jaw growth and in others growth is ahead of eruption. The ratio between these two variables changes throughout the whole period of growth. Thus, in those cases in which we have crowding, it must be kept in mind that the ratio between tooth mass and the size of the jawbone that must hold them will become constantly more favorable with growth and we do not know how much jawbone we are going to have until that growth is completed.

The length or duration of treatment also plays a very great role in determining the necessity for retention. We have fallen into the habit of considering that eighteen months is about the proper length of time for treatment. That perhaps represents the average. But in this matter again we must expect wide variation. Some cases treat beautifully in six to nine months but there are others that require a like number of years to gain the same result.

Regardless of this we tend to try to make all of them conform to the same pattern of time. Regardless of the age at which we start them we want to finish them and get them out of the office within this time limit. If a little persuasion doesn't accomplish our ends, we tend to use more force. All of our appliance therapy of the last ten or twenty years has been directed toward getting more force or more speed. In those cases in which we work slowly and gently to accomplish our aims we are frequently amazed at the speed with which we attain those aims. When such methods do not yield this type of response, the worst thing we can do is to seek to increase our forces even though the tendency is to do so.

We have very little trouble with relapse of our cases treated by cervical or head-cap traction provided we do not use too much force. The reason for this is, I believe, because we are guiding the developing denture, as Kloehn calls it, and are not exceeding the organism's ability to make adjust-

ment to the new conditions we are creating.

But the tooth-jaw relationship depends on other factors than mere size. One of the chief of these is muscle. Those muscles which influence the size and form of the arch are fastened to and controlled by the size of the same bones that hold the teeth. Since the teeth do not grow after their eruption and the jaws do, the muscle pattern at one age is no indication of what that muscle pattern will be two years hence. A dentition that appears crowded, restricted by musculature at one age, can present flaccid musculature at a later age.

The intent of this discussion is to point out that we are dealing with a living organism, an organism that undergoes constant changes as age advances. We cannot measure this growth by means of statistical yardsticks except in the broadest terms. Each of these children is an individual, unique, be the child boy or girl.

It would seem that the more attention we pay to guiding growth, whether using a complicated appliance or simple cervical traction, the more opportunity we allow for growth to stay abreast of our treatment. And the closer we harmonize our efforts with those of nature, the less need we have for retention.

Diagnosis And Treatment Of Class II Malocclusions

George R. McCulloch, D.M.D.*
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This paper is a review of treatment procedures, diagnostic facts and theories that will show what can be expected in the correction of Class II malocclusions. These malocclusions will be in both the mixed and permanent dentition, in male and female, moderate and severe. These are not new ideas or methods, but ones that I have acquired through the years. In my hands and within the scope of my ability I can now achieve results that are acceptable to the concepts of what I feel good treatment should accomplish for the patient.

The main cephalometric characteristic of a Class II malocclusion is the mandible in posterior relationship to the maxilla. This may be quantitatively expressed by comparing the angles SNA and SNB and calculating the difference, which is the ANB angle. The greater the ANB angle, the more that face appears to have an extremely weak chin or the chin appears to be retruded in relation to the upper face or dental arch.

Diagnosis

Our first consideration in orthodontic treatment is the correct diagnosis. All pertinent and important facts should be itemized if the orthodontist hopes to mold the child's teeth, features and smile into a thing of beauty and permanence.

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Presented before the Edward H. Angle Society, Colorado Springs, October, 1959.

As long as the orthodontist has to move teeth or place them in a position to resist relapse, then he should know whether there is adequate space in the arch for all the teeth free of rotations. Of the methods of determining arch length, I prefer Tweed's method of measuring the available space against the required space in the mandibular arch; his method is very precise and rapid. Especially is this information necessary when diagnosing a mixed dentition Class II. When dealing with mixed dentition cases, it is necessary to use intraoral x-rays to obtain the mesiodistal diameters of the unerupted permanent teeth. These measurements are recorded on a card and are used in the diagnosis.

It may be well to dwell for a few minutes on some facts that should be kept in mind when analyzing and planning treatment for borderline extraction cases. If there is concern about arch length in the mandible, if the incisors are crowded or a tooth is blocked out, don't wishfully think that the incisors can always be tipped a little farther forward or the arch expanded to include the blocked out tooth. The result will be eventual collapse. We should recognize where additional arch length is lost. One should remember that in each arch it requires four to six millimeters of extra space for band material depending upon how well the bands are fitted at the contact points. Another factor to consider is the additional arch length; three to five millimeters are required to level or reduce a deep curve of Spee.

There is a tendency to look only at the anterior teeth and bicuspids to judge the amount of crowding in an arch. Equally important is the position and size of the unerupted second molars and growing third molars. If the crowns of the forming second molars are sliding along the curvature of the distal root of the first molars, then it is questionable whether the first molars can be maintained during the treatment and retention period as the second and third molars develop and erupt. Poor x-ray technique can change the relative position of these teeth on the film; however, I'm confident that careful x-ray technicians obtain constant and accurate relationships of these posterior teeth. Therefore, I give a great deal of consideration to the position and size of the posterior erupting and unerupted teeth in diagnosis and treatment planning.

Care and accuracy should be paramount in tracing lateral head films so that valuable diagnostic information will not be lost. Good tracings should clearly show the areas used for registration points as well as the sites of tooth movement and bone growth. The component parts of the face and skull do not always grow and develop in an orderly manner; we often superimpose one area at a time to note changes in tooth movement and growth[2]. With good tracings all types and ways of superimposing are possible; in this way more can be learned about orthodontic treatment procedures and their results.

Orthodontists must recognize limitations in the treatment of some cases, especially severe Class II malocclusions. Our greatest limitations and compromises occur most often when we treat severe Class II malocclusions after the main growth period has passed for that child, usually in a girl eleven and one-half years and older or a boy over fifteen years. We are also often forced to be satisfied with less than ideal results when treating severe Class II malocclusions with extreme facial skeletal patterns and growth deficiencies. On the other hand, however, there are the Class II malocclusions that have a skeletal pattern in which the mandible is quite normal in size, shape and position relative to Frankfort plane but is decidedly retruded in relation to the maxilla and upper face. When faces are within the latter range, they can be designated as having a good basic facial pattern. The ANB angle is, roughly, the guide as to the severity of the Class II malocclusion; a case can be classified as mild when the ANB angle is three degrees to five degrees, severe when the ANB angle is five degrees to eight degrees, and disfiguring when the ANB angle is eight degrees or more.

In treatment planning one should take into account the mandibular plane angle as well as the shape and size of the mandible. One need not be so concerned with the excellent mandible well-oriented to Frankfort plane; in these cases there nearly always seems to be a sufficient chin which improves with growth and treatment. In mandibles not so favorably located in reference to Frankfort plane, I am convinced that we can often make notable changes in the bony and soft tissue profile in the area of the chin. Many times the chin button can be increased when the mandibular plane angle is reduced and when the anterior teeth and their bony support are moved lingually.

The mandibular plane angle is seldom reduced much during treatment; however, some bone deposition can be shown on excellent mandibles during the treatment period, especially on growing males. The lingual movement

of the mandibular anterior teeth and their alveolar bone is the main contributing factor in developing a more prominent chin. This can be accomplished more readily in the mixed dentition.

The distance between the extension of the line NB and the pogonion point on a lateral head film tracing expresses the amount of bony chin or the chin button. The soft tissue chin usually conforms very closely to the bony chin and the amount of chin button reflects the degree of strength in the soft tissue profile of the lower face. It is very difficult to estimate the amount of chin a child will develop during growth. Male adults, on the average, have more chin button than female adults and growth continues for a longer period of time in the male. Mandibles that are more nearly parallel to the Frankfort plane (low mandibular plane angle) tend, as we know, to develop a good chin button. Likewise, there is considerably less chin button in the steeper mandibular plane angle cases.

The lack of a chin button makes the profile seem worse, while the greater the chin button, the better the profile appears. Holdaway shows the importance of the chin button by coordinating it with Point A to Point B and the angle of the maxillary and mandibular incisors.[2] When his formula is followed, a most pleasing profile may be obtained for the patient. The Steiner analysis likewise takes into consideration these important measurements.[3]

Treatment

One should exercise great care in the treatment planning in all cases but especially in those with an excellent basic facial pattern and a good potential for more growth. It is wise to be conservative where growth and treatment may possibly help to develop considerably more chin button.

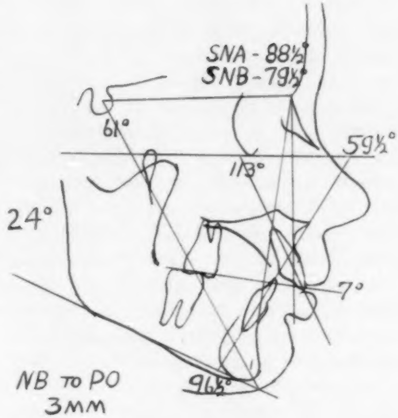

Fig. 1

One can expect excellent results with good orthodontic treatment in the Class II, Div. I malocclusion shown in Figure 1 because this eleven-year old boy has an excellent basic facial pattern with a favorable growth potential. One can approach with confidence, however, the treatment of severe or disfiguring Class II malocclusions in which the basic facial patterns are not good. When confronted with this type of case, one should not compromise treatment; instead, do everything possible to give the patient a well-balanced and harmonious face. With the application of sound mechanical procedures, points A and B can be repositioned farther lingually. If the age factor is favorable and there is growth during the treatment period, one can expect a sizable reduction of the ANB angle and a favorable increase of the chin button.

Case #436, is a boy, aged nine years and ten months, with a disfiguring Class II, Division I malocclusion. The chin is weak and ill defined (Fig. 2). This mixed dentition case (Fig. 3) displays a deep overbite in the incisal area; the models show some crowding and protrusion in the maxillary and

Fig. 2

Fig. 3

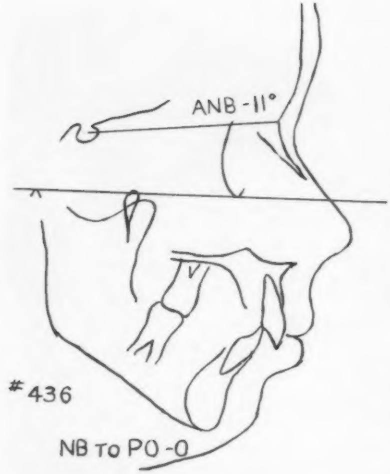

Fig. 4

mandibular anterior region. The full mouth x-rays revealed a notching and bifurcation in the bone between the upper centrals. A frenectomy was performed after first closing the space.

The lateral tracing (Fig. 4) displays a severe ANB angle with the entire maxillary arch forward. The lower border of the mandible is steep; there is very little chin, thus the entire face is very convex. The maxillary incisors are bodily forward and too upright; the

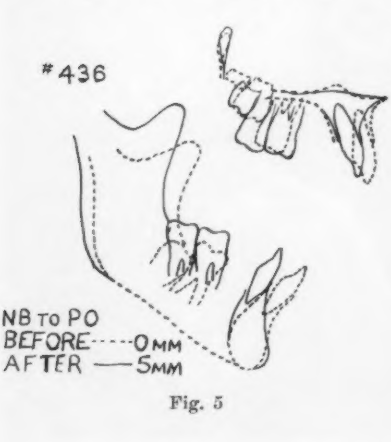

Fig. 5

mandibular incisors are tipped labially of their basal bone.

The maxillary incisor teeth and the first molars were banded and the case was given headgear treatment for six months. Then all four first bicuspids were removed and the remaining teeth, both permanent and deciduous, of both arches were banded. The treatment procedures followed were those advocated by Tweed for mixed dentition, Class II, extraction cases.[5]

The before and after treatment tracings of the two mandibles are superimposed on the lower border at the lingual symphysis to show the changes of the incisors, point B, and the chin button (Fig. 5). Point B, in the after treatment tracing is decidedly lingual by seven to eight mm. and there appears to be deposition of bone on the most anterior portion. There has been considerable growth in this mandible. The body and the ascending rami have had good growth along with increased alveolar heights in the posterior area. A great deal of the facial improvement is due to a change in the chin button, brought about by the retraction of point B and forward growth of the mandible. Looking at the maxillas, superimposed on the hard palate (Fig. 5), you will notice the lingual bodily movement of the maxillary incisors along with their good axial inclination. This case was very favorable for this type of movement because there was sufficient bone to move these teeth lingually, thus greatly reducing the SNA angle.

The after treatment tracing (Fig. 6) shows a well-balanced face that is within normal limits for profiles exhibiting rather a steep mandibular plane angle. The maxillary and mandibular teeth are now in a stable position on basal bone and in a good Class I relationship.

Because there was considerable

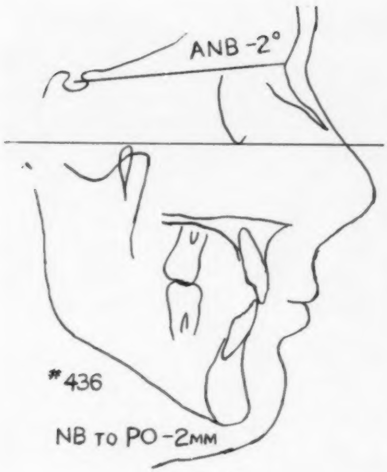

Fig. 6

growth between the before treatment lateral head film tracing and the final posttreatment tracing (a time lapse of four years and two months (Fig. 7), it seems that a better comparison of growth and treatment changes could be shown in the middle and lower third of the faces by superimposing

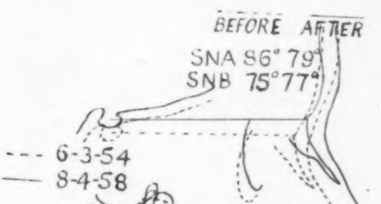

Fig. 7

the tracings on the hard palate and the anterior nasal spine. Vertical growth occurred in both the upper and lower face. Horizontal growth occurred mostly in the mandible, some between sella and nasion and very little in the maxillary area. His photographs show the soft tissue improvement when teeth are moved bodily and point A and point B are repositioned (Fig. 8). Even though the mandibular incisors and point B were moved lingually, forward growth of the mandible slightly increased the SNB angle. The decided increase of the chin button greatly reduces the convexity of the lower third of the face. I believe that treatment was started at an advantageous period and the mechanics of treatment were such that these favorable results were made possible. The soft tissue change has kept pace with the skeletal changes giving normal tone to these tissues.

When treating severe Class II mixed dention cases, it is usually advisable to treat thoroughly and accomplish as much as one can while the deciduous teeth offer good resistance, then retain and wait until all the permanent teeth erupt. At that time a short period of treatment should finish the case quickly.

I feel the two phases of treatment in this case have given a more permanent and gratifying facial change than could have been obtained by waiting until all the permanent teeth had erupted and treating only in the permanent dentition. Total elapsed time was three years and nine months with but two years of banded treatment including both deciduous and permanent dentition work.

The lateral head x-ray (Fig. 9) for patient #547, was taken when this girl was eleven years and three months of age. Models and photographs were made two years later and treatment was

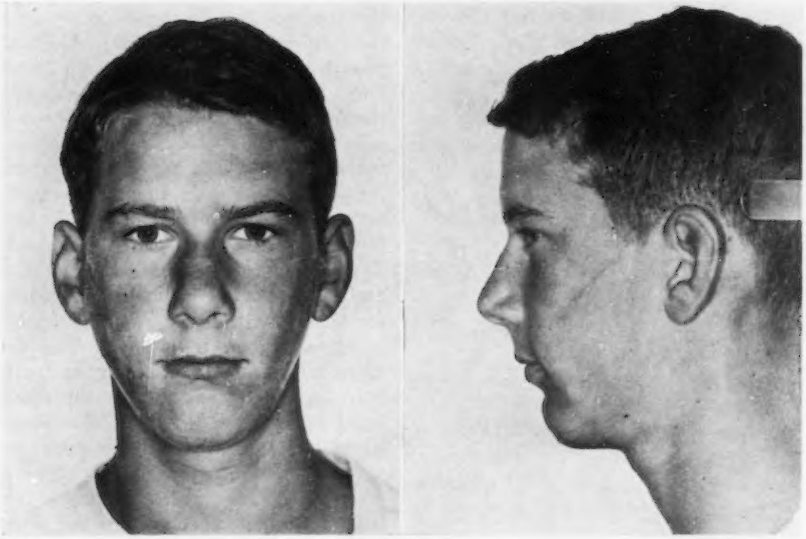

Fig. 8

started in another few months. By tooth classification this case would be designated as a Class I malocclusion, but by skeletal and soft tissue profile, we must change this classification to a Class II, Div. I malocclusion of moderate severity (Fig. 10). The mandibular first molar on the right side was submerged due to bulbous roots. The mandibular incisors are tipped forward and slightly crowded (Fig. 11); the overjet is fairly severe, the overbite quite deep, but there is a good basic facial pattern. Even though the patient had a good chin button, it was decided that extractions were necessary to attain the best esthetic balance and stability of the dentures. Therefore four first bicuspids were removed and treatment inaugurated for Class II, Div. I type of malocclusions.

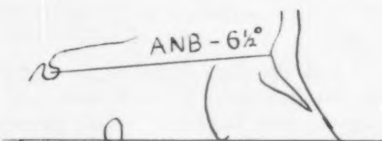

Fig. 9

The after treatment tracing was made shortly after the case was retained. The convexity of the face has been eliminated through growth and treatment. Both the maxillary and mandibular anteriors are now well over basal bone.

The before and after tracings are superimposed on SN at nasion (Fig. 12). Without too much over-all growth, this point is adequate for show-

Fig. 10

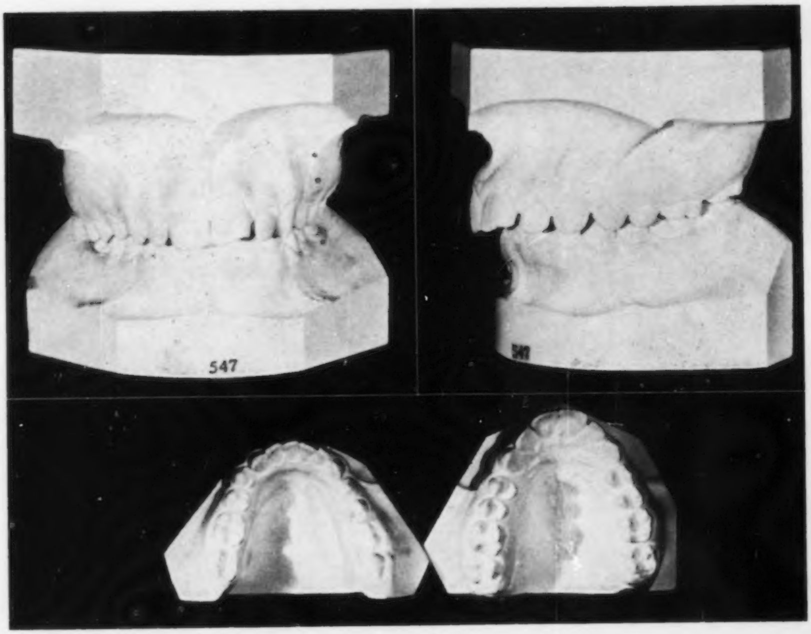

Fig. 11

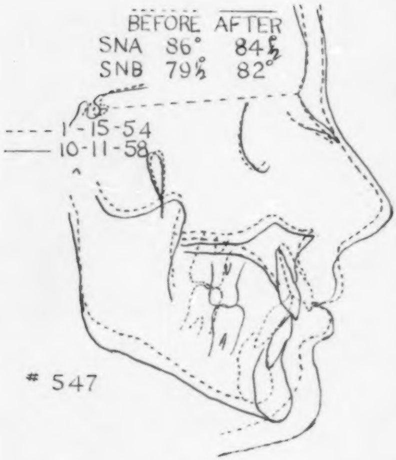

Fig. 12

ing general profile changes. The elapsed time between these two tracings is four years and nine months. During that time there was some general overall growth with a much greater amount in the mandible and a lesser amount

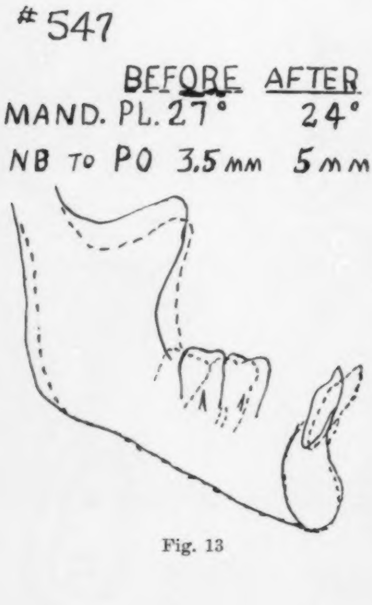

Fig. 13

in the maxilla. The forward growth of the mandible was the main contributing factor in reducing the facial convexity so noticeable in the soft tissue change in the lower face. The other sources in reducing the convexity were the slight lingual repositioning of point A and the bony deposition on the chin.

The before and after mandibles are superimposed on the lingual symphysis (Fig. 13). Besides the lingual positioning of point B which helped increase the chin button, there was some bony deposition on the most anterior portion of the chin. There was also a decrease of the mandibular plane angle of a few degrees. The submerged mandibular right first molar was brought into normal occlusion. The models also show a well-balanced denture that should be stable during and after retention (Fig. 14). The final photographs are seen in Figure 15. Total treatment time was two years and two months.

A Class I malocclusion in a girl age eleven years, six months was included to illustrate what can be accomplished in children where there is little or no chin button (Fig. 16). Other than a high facial angle everything is normal except the chin. If there had been an adequate chin, the face would be very pleasing instead of being a Class I double protrusion in appearance. The case was treated as a double protrusion with the removal of the first bicuspids, even though there was an excess of space in both maxillary and mandibular arches. Treatment planning called for the retraction of both the maxillary and mandibular anterior teeth as far as possible.

The before and after tracings are illustrated in Figures 17 and 18. There is a lapsed time of two years three months between the tracings. Treatment results show that favorable facial esthetics

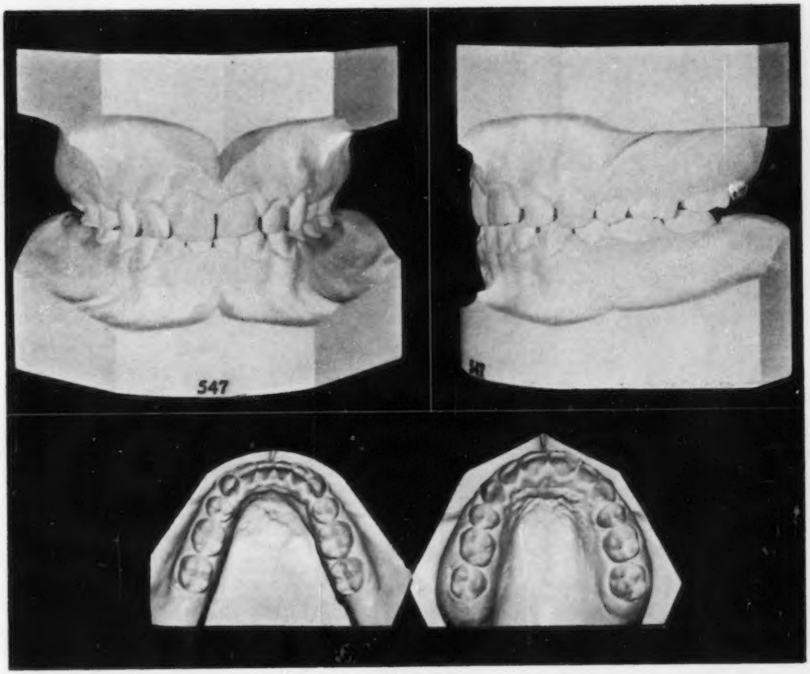

Fig. 14

Fig. 15

Fig. 16

were obtained. This was a compromise treatment because the teeth were placed lingually on the denture base. Figure 19 depicts the models before and one year after treatment. There now is two mm of chin button and point B is six mm lingual of its former position. This, plus the reduction of point A an equal amount, gives the profile a better balance (Fig. 20). This girl was also a perverted swallower, which took many months of habit cor-

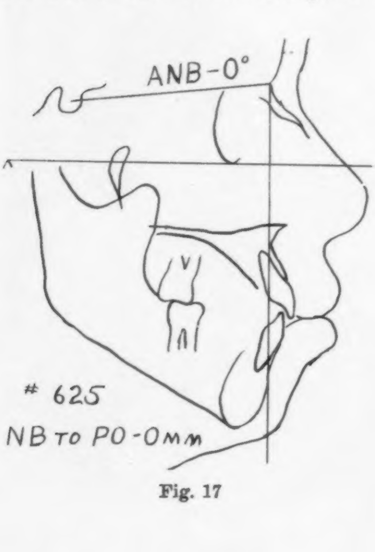

Fig. 17

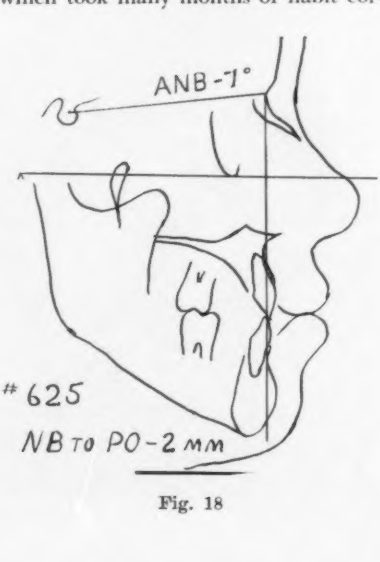

Fig. 18

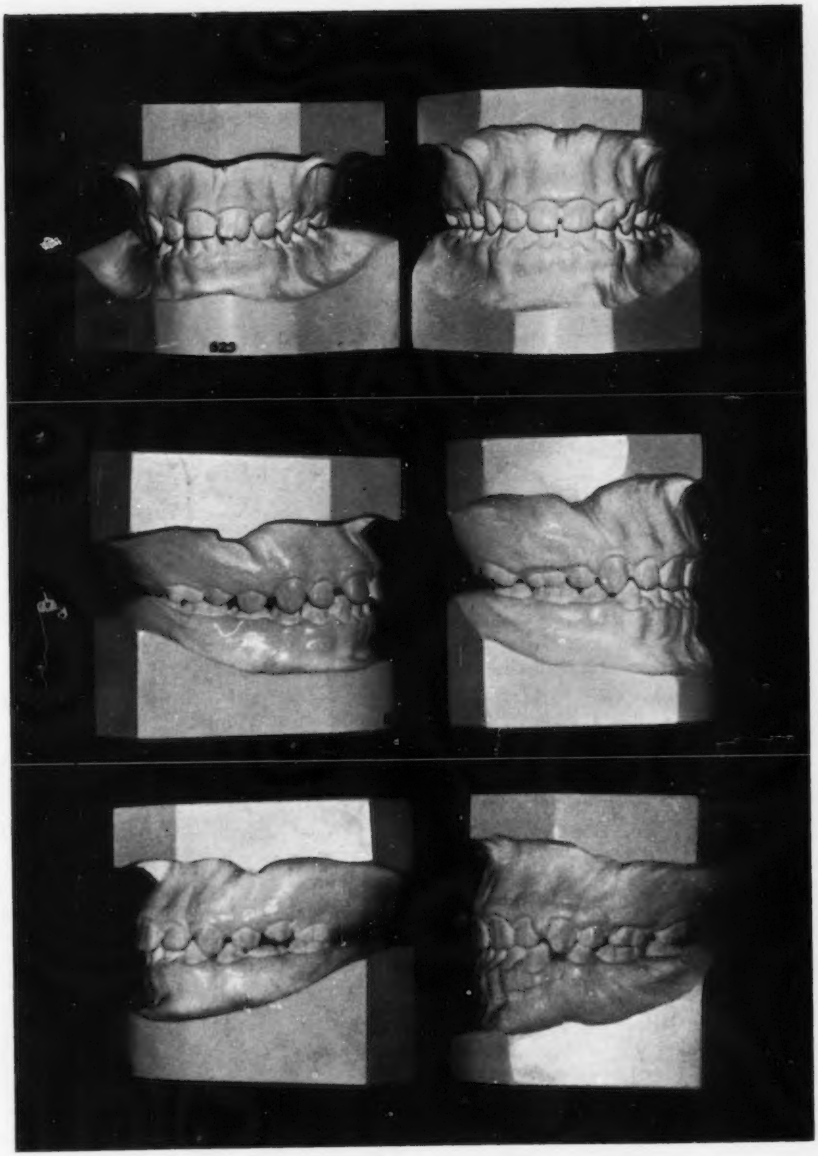

Fig. 19

Fig. 20

rection therapy to be assured that retention was stable.

The positions and sizes of unerupted second molars were mentioned earlier. Figure 21 (above) shows second molars with plenty of room to erupt. When treating a case with similar spacing in the unerupted second molar area, with a slight anterior discrepancy, the chances of holding the first molars from mesial drifting are very good and with the added possibility of gaining a little more space. Also these molars can usually be tipped well back in anchorage preparation with little or no forward root movement.

Figure 21 (below) illustrates the x-rays of the same mouth taken two years later. You will notice that there is still room for the second molars to erupt and so far they are erupting normally. If one extracts in a borderline case, even though it may be a Class II with posterior spaces like this, he may have a difficult job finishing the treatment. I am now careful to note the size and position of second molars and I think we should consider later the third molars in this same light.

Second molars that are crowded against the roots of the first molars can be seen in Figure 22 (above). The chances of their erupting into good positions without affecting the first molars are very slight. Their tendency while erupting is to move the first molar farther forward in an already crowded and shortened arch. When extracting in a case that shows this

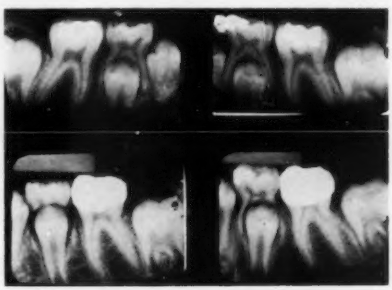

Fig. 21

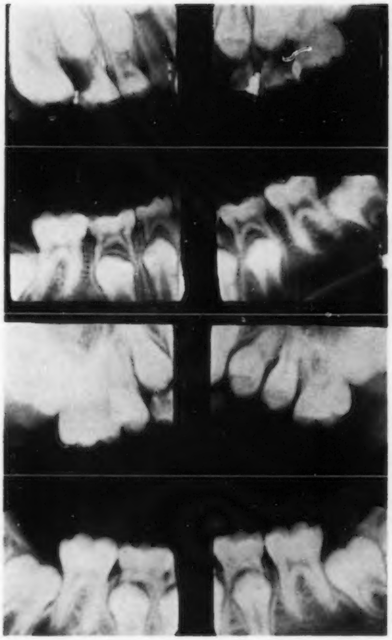

Fig. 22

much crowding it often seems that the posteriors move forward more and faster than the anteriors go lingually during treatment. The extraction space seems to melt away. The upper first molars were even locked into the distal portions of the second deciduous molars. Note the position of the second mandibular bicuspid to the roots of the second deciduous molar; the same case a year and a half later (Fig. 22, below). It appears that the mandibular deciduous second molars have been pushed forward from their normal positions so that the first and second bicuspid crowns are not in the same relative positions with the deciduous molar roots. The second molars in the maxillary arch seem to have insufficient room to erupt. The long axes of the mandibular first, second and third molars tend to converge at a point just above the occlusal of the first molar. With the second and third molars erupting in this direction, it appears that they will certainly adversely affect the cuspids and bicuspids that are also in the process of erupting, and later the four incisors.

It was previously stated that additional arch length is necessary when a deep curve of Spee is reduced. This is important to consider in borderline extraction cases along with anterior and posterior crowding of the erupted and unerupted teeth.

Any one of us would prefer to treat cases with low mandibular plane angles rather than angles of thirty degrees and above. The low angle cases usually have a better growth pattern which can be more accurately predicted during treatment than can high angle cases. Also, the low angle cases usually have more chin button and a good chance of additional growth during treatment. One should remember that the chances of bettering the profile in cases with mandibles having a steep angle are decidedly poorer than the low angle mandible cases. Two mandibles of the same length and shape will give two distinct patterns in the lower portion of the face when in one case the mandibular plane angle is twenty degrees and the other at thirty-five degrees. The twenty degree mandibular plane angle face will generally be straight with a definite chin. The thirty-five degree mandibular plane angle face will be more convex, longer in the lower third of the face and have a less prominent chin. The same amount of chin button on two mandibles, placed side by side, will vary greatly when placed under Frankfort planes at the different degrees. The same amount of growth in these two mandibles will, in the low plane angle case be mostly forward, while in the high plane angle case it will be more

downward. By the same token the twenty degree angle case usually has a flatter occlusal plane. Equal mandibular bone growth will allow more room for teeth to erupt in the lower angle mandible.

These are some of the reasons good basic faces improve with treatment, while the poor basic faces often improve very little. Sometimes the mandibular growth in high degree angle cases is so slight that SNB is less after treatment than before treatment.

For these reasons I am convinced that one should use every effort to keep the upper and lower anterior teeth from elongating. One should not steepen either the occlusal or mandibular plane but flatten them, if possible.

One can expect to bodily move any or all teeth in the mouth under optimum cooperation. The limits of tooth movement are the amount of basal bone that exists, the time involved and the condition of the tissues. Obviously it is foolish to move a tooth until the root is badly absorbed. Tooth movement, when done on younger patients eight to eleven years of age, is much faster, generally more permanent and shows less damage to the hard and soft tissues. Good tooth movement, as we all know, is possible in older patients, even though the growth period is practically finished.

Much of the success of Class II treatment depends upon the handling of the maxillary incisors; in severe Class II malocclusion they usually erupt until they are supported by the lower lip, in a more or less stable position. The treatment plan should call for the retraction of these teeth without elongating them; many times we even plan to depress them. Because the maxillary incisor roots are conical in shape and because of their tipped-forward position, the tendency during their retraction is for the crown to go lingually and incisally. To bodily move and maintain these teeth in a good axial position, in the neighborhood of 110 degrees to Frankfort plane, requires careful procedures in torque control, elastic forces and headgear assistance.

One of the common contributing factors to minor and major collapse of treated cases is perverted tongue and swallowing habits. The tongue is generally the most serious offender.[4] If normal swallowing and tongue thrusting habits have not been corrected where they have been a problem, then the finest treated case may collapse from these abnormal muscular pressures.

Summary

In summarizing, the essayist would like to stress the following facts:

(1) The gross improvement from treatment of severe Class II, Div. I malocclusions is brought about by the reduction of the ANB angle. This is accomplished by lingual positioning of point A and forward positioning of point B.

(2) When it is necessary, improvement of the chin can be accomplished by lingual positioning of the mandibular incisors and point B.

(3) It is necessary to establish and maintain excellent anchorage to accomplish these gross tooth movements.

(4) Coordinating treatment with the best growth period. The degree of favorable orthodontic change is related closely to growth. Many of these changes can be accomplished, to a lesser degree, in nearly matured children.

While treating a Class II malocclusion we should keep in mind the three basic principles we are striving to obtain: (1) pleasing esthetics, (2) stable dentures, and (3) least possible damage to the teeth and tissues.

These basic treatment necessities are carried through most successfully when the appliances are kept simple and progressive, when the case progresses rapidly with adequate forces used, and above all, when we receive excellent patient cooperation.

Fourth and Pike Bldg.

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Dr. R. H. W. Strang

I do not hesitate to pass personal judgment that Dr. McCulloch is a most expert and outstanding orthodontist; however, I cannot help but differ with the essayist in his statement of what a Class II malocclusion may be. I firmly believe that the position of the mandible and its superimposed denture designates Class II and Class III from Class I. True, we may find borderline cases that may be classified either way but it seems to me that the basic principle for classification should be located in the growth pattern of the bones rather than in the occlusion of the teeth.

From research reports it seems questionable whether any tooth movement can be held responsible for added growth in the bone extraneous to the alveolar process. Camouflaging deformities seems to be one of the prerequisites of our specialty. If natural growth then adds to our efforts, we are just fortunate.

I certainly agree with the essayist in his emphasizing the fact that we are wise not to attempt to improve certain cases in which errors of occlusion and esthetics are of minor degree. Also that it is essential to consider carefully deficiency in growth posterior to the first molars as well as anterior to them. Extraction of maxillary second molars, where third molars are present, is very practical in certain cases. On the other hand, I believe it is a mistake to extract second mandibular molars as a treatment procedure because of their importance as anchorage auxiliaries in eliminating excessive overbite and maintaining the correction subsequent to treatment.

Dr. McCulloch's paper exhibits painstaking preparation and expert treatment procedures. It warrants careful study when published.

Dr. George Hahn

You have just listened to an excellent paper in which Dr. McCulloch, in a very able manner, has presented the modern concept of diagnosis and treatment of Class II malocclusions. To expect all of us to agree fully with what the author presented would be incredible, although I am sure that it will be more in tune with the thinking of the younger men in the profession than it will with those of us who have had the opportunity of observing our successes and our failures over a long period of years. Because I do not subscribe fully to all that is offered in the new philosophy of orthodontic diagnosis and treatment planning I am labeled by some of my contemporaries as an antiquated orthodontist. Be that as is may, it is from such a perch that I will briefly discuss this paper.

I like Dr. McCulloch's statement, and I quote, "The lateral headfilm

and resulting tracing has proven to be a very important aid in diagnosis. Possibly too much emphasis is placed on lateral headfilm tracings. Maybe we are looking at lineal profiles with angles, degrees and millimeters too much while forgetting about the patient as a real person". At the moment so much emphasis is being placed on the forty-five (at the time this is written) methods of diagnosis by geometrical formulae that the value of a little horse sense in treatment planning is largely overlooked. Someone has well said that any of these analyses at best can provide only a generalized guide and can all too easily lead the unwary astray.

There is one question that we could afford a little time to pray over. Are we treating to develop a preconceived facial pattern for a teenager or should we not be giving some thought to the health, stability and longevity of the human dentition?

After all it isn't so much the anatomy of the face that makes a person attractive. It's the soul of the man that shines through. Give almost any normal human being of mature age a satisfactory occlusion with reasonable prospects that it will be buried with him and you don't need to worry too much about the facial pattern. Look about you.

The face and dentition of the child because of its inherited characteristics and the fact that it is an ever-changing and growing and developing part of the human body should not automatically and with finality be subjected to predetermination by geometric analysis, which, as used by many present day orthodontists, disregards the individual as such in favor of the average. Fortunately Dr. McCulloch has repeatedly called attention to this in his paper.

Dr. McCulloch has discussed at considerable length the chin button and its place in the human face with special attention as to when and in which cases orthodontic treatment should be directed toward its development. Unless one is absolutely sure of his ground it is dangerous to overemphasize this one feature in the formative period. In many individuals the normal development of the so-called chin button is coincidental with maturity. If you want your patient at thirty-five to look as though a mule had kicked him in the face at six years of age go ahead and deliberately build a chin button.

I cannot fully agree with Dr. McCulloch's statement, quote, "If we are concerned about arch length in the mandibular arch and the case is slightly crowded or a tooth is partially blocked don't wishfully think that the lower anteriors can be placed a little forward or the arch expanded without eventual collapse". Almost any orthodontist with sufficient years of practice behind him to have observed his patients grow to maturity can point with justifiable pride to such cases treated before the extraction era in which arch length was increased and a reasonable amount of expansion was obtained and the end result was permanently satisfactory. However, to stimulate this growth or development, or whatever one chooses to call it, it is almost essential that treatment be first instituted before the completion of the twelve year old dentition.

It will be interesting to those of you who are still able to say "aye" when the roll is called twenty years from now to revaluate the results of what at the moment appears to completely satisfy the requirements of modern orthodontics.

Dr. Howard M. Lang

The paper just presented by Dr.

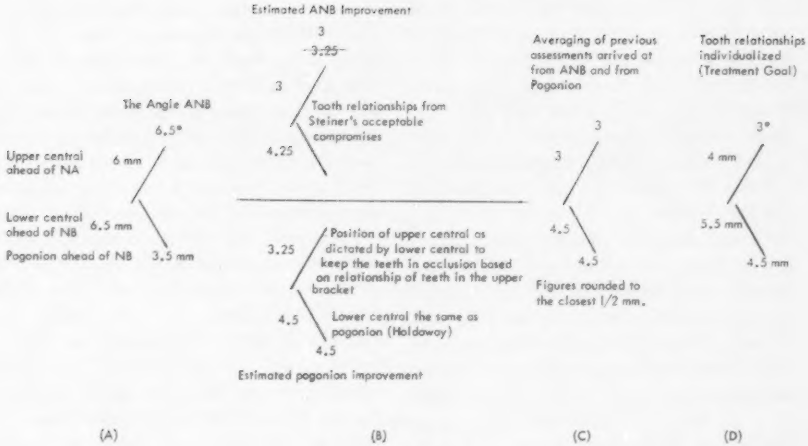

Fig. 1

McCulloch has shown admirably how teeth were moved from extreme positions of malocclusion to most favorable relationships of balance with each other and to their bony structures with tissue harmony. In examining the cephalometric tracing of case (J.H.) #547, you find a very good facial pattern with good forward growth potential in the lower part of the face of a girl eleven years, three months of age; it is most unlikely that she has reached her full facial maturity.

Your panel of discussers, Dr. Hahn, Dr. Strang and I feel that perhaps this case could have been treated with excellent results without extraction. Whenever you find a symphysis possessing the characteristics of this one shown in the tracing, where pogonion is three mm ahead of the line NB, you can expect additional favorable changes of bone deposition and facial balance as adulthood is reached. With a mandibular plane angle of 27° with Frankfort, or as I have measured it 33° with the line SN, we observe another favorable reading for good mandibular growth potential. This is further verified by the measurement SL (from the Steiner analysis) which is 58 mm, whereas the average length has a reading of 51 mm.

In analyzing this case by applying the Steiner analysis we would arrive at the treatment goal in the following manner (Fig. 1).

In determining the treatment procedures to arrive at our treatment objective, we must observe what has to be done with the mandibular teeth. Thus we shall use the procedure from the Steiner analysis as shown below (Table I).

TABLE I
Lower Arch

Increases total arch length +	Decreases total arch length −	
	2	Arch length discrepancy
0	0	Possible expansion
	2	Repositioning $\overline{1}$ from 6.5 to 5.5
1	0	Repositioning $\overline{6}$ by uprighting
0	0	E Space
	4	Cl II elastic pull
0	0	Extraction
	—7	Net arch length

If Class II elastics were not used there would be only three mm of arch length to be gained in the lower arch. Surely with the good results you have shown, you could have gained this much arch length discrepancy and held it. Therefore, with good treatment procedures, extraction in our opinion was not necessary.

In the analysis of this case (Table I) we planned on moving each molar distally one-half mm but, I am certain, with Class III elastics as used in anchorage preparation we could increase this to the amount required; or by expanding sufficiently to pick up one mm of arch length we could lessen the amount of distal movement. In Figure I D, our treatment goal relationship of the lower central to pogonion is one mm ahead of the pogonion measurement. As Holdaway points out, in favorable growth patterns a difference of two mm is acceptable; thus by moving this tooth one mm forward we have increased arch length by two mm. As you see, there are numerous possibilities of getting the lower teeth into acceptable alignment with their bony structures. By "setting up" sufficient anchorage the maxillary protrusion could be overcome in the usual manner; or one could properly position the mandibular teeth and then, by using a Kloehn type face bow, move the maxillary teeth distally to their correct relationships with their opponents.

Many of us have observed that a slightly protrusive denture in a young adult will not appear as such when growth changes occur and facial maturity has been reached. A plea for caution in extraction of teeth in this age group is indicated. This young girl's face, we feel, is now too flat or concave. If you will draw a line from the anterior portion of the fleshy chin to the anterior portion of the upper lip and extend it upwards until it reaches the line SN, as Holdaway advocates, you will see that most of the nose appears ahead of the line. For a well-balanced face of a young adult I would like to see this line split the nose. In other words, there should be as much nose behind the line as there is in front of it. Using Holdaway's angular measurement of this line to SN we find a reading of 76°. When comparing this with the angle SNB, 82°, we have a difference of 6°, or this facial line with the NB line forms an angle of 6°. Dr. Holdaway states that favorable differences range from 6° to 9°. Thus from this assessment we also find the face on the concave side. Therefore we feel that extraction was not indicated cephalometrically.

In the paper Dr. McCulloch pointed out nicely the important diagnostic relationship that the lower second molar has to the first molar in determining whether there will be sufficient arch length after its eruption to accommodate all teeth without crowding. If the second molar is in a position where it is partially locked under the height of contour of the first molar, there will undoubtedly be considerable mesial drift of the teeth anterior to it unless proper steps are taken to minimize it.

In the mixed dentition stage at the loss of the lower second deciduous molars, the first molars need not be allowed to drift appreciably forward to crowd the teeth anteriorly. Arch length can be saved to allow a slightly crowded condition to be unravelled by keeping the molars where they are, or by moving mesially-inclined teeth distally. You will observe a mesial drift of 1.7 mm of each lower molar, as Dr. Nance pointed out, when the mesial buccal cusp of the upper first molar is mesial to its normal functioning relationship, i.e., mesial to the buccal groove of the lower first molar. This condition oc-

curs when the upper second deciduous molar is narrow mesiodistally. The first molar therefore erupts forward of its normal functioning position and must be moved distally by extraoral force if lower arch length is a problem. When the molars are properly locked in occlusion, I have observed less mesial drift of these teeth with some lingual movement of the lower anteriors. Thus pogonion appears to be more prominent, just as it did in these cases of Dr. McCulloch's where he has moved the anterior teeth bodily lingually.

When there is a question of holding the arch length after treatment, I would recommend a cemented lower cuspid to cuspid retainer to be worn many years along with a lower Hawley retainer to assure more favorable stability of the denture.

Dr. McCulloch stressed the importance of maintaining arch form and cuspid width — a most important point. However, in extraction cases cuspids may appear a little wider than the original malocclusion due to the movement of these teeth distally into a wider area or "channel" of bone. This slightly greater width, I have found, can be maintained very satisfactorily.

Thank you again Dr. McCulloch for your paper showing excellent tooth movement and orthodontic results. All have enjoyed hearing it and will look forward to studying your article in detail at their leisure.

Dr. McCulloch

It has been brought out in the discussion of this paper that Class II nonextraction malocclusions were not specifically mentioned nor used in any of the illustrations. The omission of nonextraction cases is not due to the lack of suitable material, but to the more pronounced facial changes that can be shown in many of the severe Class II malocclusions in which the removal of teeth is necessary. The amount of ANB angle decrease can be shown as well in the nonextraction Class II as in the extraction Class II malocclusions, but the lingual positioning of point B can be carried to greater degree in the extracted malocclusion cases, thus showing more of an over-all chin button increase.

The necessity of removing the first bicuspids in case #547 is questioned. If I were now treating this case or similar cases, I would apply a lingual tipping force on the mandibular incisors rather than bodily moving them lingually over basal bone. In these cases with an already adequate chin button, we would expect less chin button change by not disturbing point B, and that can be done by careful tipping control of the mandibular incisors.

Laminated Arch Technique - A Progress Report

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The mechanics of treatment is the objective approach to the correction of malocclusion. It is the applied therapeutics, the prescription specific to the malady. It is, necessarily, by virtue of the complexity of the prescription a serious, painstaking mechanical process which requires of the operator a high degree of skill to fulfill the requirements which have in recent years become a scientifically exacting and demanding set of objectives.

It was relatively simple twenty-five years ago when our concept of treatment was to alter the arch form, level off the occlusal plane, and reposition the maxillary units into harmonious cuspal relation with the mandibular teeth and then let nature take its course.

Now we have progressed to the point where we set our sights much higher and we have a prescription to fill which demands that we relate all of the teeth and the bony processes in which they are imbedded to the cranial structure of the head. Dr. Angle had insisted that normal occlusion was this very thing, but our prescription did not specifically make this demand because our therapeutics simply could not measure up to the requirements and our diagnostic equipment was not adequate to give us specific information to point out clearly the deviations from the normal.

The information was actually there if one were to examine the patient carefully. There were men who could make an accurate appraisal of the deviations without our modern cephalometrics, but they limited their own possibilities by not having a set of standards and a detailed graphic report on what they saw.

Actually the mechanisms used in treatment today, by and large, have not improved significantly in the last twenty years. Manufacturers now provide us with appliance assemblies formerly devised by the individual orthodontist. In this manner the entire profession is benefited. These accessories and the whole equipment armamentarium save us many hours of time and enable any competent operator to set up an appliance which will look respectable and do the job if properly directed.

We should progress towards better mechanics even though our present appliances perform well. The gasoline piston engine has been for sixty years a great boon to transportation and, although it is adequate, it will probably be replaced by the turbine engine or something better. The point I wish to propose is that our basic treatment instrument, the archwire itself, may be wrong in principle whether it is round, oval, rectangular or square. It does not have the resilient qualities in the bulk which are required for manipulation. It is easily formed by hand and simple to apply but it does a very clumsy job in the fine, delicate force control expected of it when seated in slots with a thousandth of an inch tolerance deviating off line from its axis. When we reduce the dimensions below .021x.025 we encounter difficulties in forming the wires without torque and

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the bracket slots become so small it is hard to see the relation of wire to bracket. This has been tried and offered to the profession but has never been popular.

Laminated arches, I believe, are the answer until we find something better. By using the rectangular archwires, each one-half the thickness of those in common use, we have the same dimensioned wire to which we are accustomed but with properties which allow far greater resiliency and thus prolonged extension of force without initial shock for the tissues. The archwires no longer need be formed by the operator but are made on dies by the manufacturer in various sizes. No soldering operations are necessary. Closely adapted tube-stops, hooks and coil springs are in the assembly of the fabricated arches and can be moved to required position and set if desired by compressing with an instrument and moved again and reset if space demands.

After fifteen years of experience with these wires I have settled upon a standard dimension of .021x.025 or two wires .0105x.025. This gives adequate strength with arch form, good resilient action and is large enough to manipulate without eye strain. The second order bends, though rarely used with angulated brackets, and torque are applied with a square plier S.S. White #142 with a .022 square slot. Two of these pliers are used where anterior torque is indicated. Because the archwire, split horizontally, does not have great strength vertically in such required action as depressing the anteriors, we exaggerate the bends or contours. Laminated wires split vertically have great strength in this direction but have shortcomings in their resilient action in the bracket slots and a weakness in a lateral force. Their virtue is somewhat limited for our particular requirements. Because of the experience of limited success with these arches and conclusive evidence presented by Dr. Cecil Steiner in his paper on "Power Storage", I have reverted to the split edgewise type. Exaggerated torque bends fit into the anterior bracket slots so easily that one feels immediately the lack of faith in the ability of the arch to perform the required root action. Not only does it perform well, but also when the arch is removed, the torque is still present in the wire and has not been dissipated as is common with the solid arch.

Because of its great extension of force fewer arch changes are required. There does not seem to be the tendency for overexpansion in the finishing archwire that we encounter in the heavy rectangular solid wire.

In the space closure operations of extraction cases it is particularly advantageous. Either the long Bull type loop or the rounded loop may be used[2]. The long loop as employed by Dr. William Thompson and a modified long loop of Dr. Max Fogel both produce excellent results in their hands. I prefer the round loop or safety pin type because it has greater strength and does not have the weakness that right angle bends impart. This is used largely for root movement of the cuspid, the crowns of these teeth having previously been tipped distally[3]. Even though the brackets are angulated we apply this archwire to the premolars and cuspids with the inverted loop in the center of the extraction space and the section anterior to the loop at a 45° angle to the posterior portion. The anterior section is not applied to the centrals and laterals at this time but is far gingival to these teeth until seated in the cuspid brackets. The loop itself is not used primarily for closing the crown interspace, but is only an

auxiliary to the small coil springs, one in front of the molar stop and one mesial to the cuspid, because at this point not much closure is necessary, it having been accomplished previously with the loop lingual archwire during the preliminary Class III stage. This stage, an important phase of the treatment plan, is very simple and effective. The lingual wire is first applied passively while we are waiting for maxillary stabilized anchorage. After this anchorage has been set up with the side loop sections and stabilizing plate, Class III force is directed against the key loops mesial to the cuspids. The molars are tipped distally in a very short time and they are followed by the cuspids and bicuspids. Even the anteriors begin to follow them. At this point, approximately six to eight weeks, the lingual wire is cut away, the bicuspid and cuspid bands are placed, and we are ready for the laminated loop archwire which will move the cuspid root faster than anything I have seen in operation. After condensation of the lower arch the second molars are banded with angulated tubes. The first molars still have their tubes which are left on. Because of the resiliency of this arch the new laminated finishing wire is placed and can be threaded quite easily through the tandem tubes. This helps substantially in supporting mandibular anchorage. I have been quite surprised at the stability of a laminated wire which is weakest in the vertical direction when called upon to support an anchorage unit to which heavy elastics are applied in the Class II stage. I must admit that my fears led me to believe that the last molar would elevate and thus I felt bound to change at this point to a heavy .021x.028 wire. This I found to be erroneous. Because of the proximity of the last two molars and the short arch section exposed between them it was not affected by the pull of the elastics. If anything were to be affected it would have to be the short section of the wire distal to the last molar, and this was too short to be of any consequence. Also the root actions between cuspids and bicuspids continue to function by virtue of the resilient force exerted by the straight laminated wire passing through the angulated brackets on these teeth.

In conclusion I would like to say that those of us who are using these arches are very enthusiastic about their performance. Now that they are available for all without a technician to prepare them I hope more of you avail yourselves of the pleasure which I am quite sure that you will derive. The ease with which they are seated in the brackets relieves the tension from our work. The patients are happy because they do not experience the shock of heavy abrupt forces. Lingual root torque of the anteriors which can be a difficult operation and a painful one is, I am sure, much more easily accomplished. The feel of these arches when one first starts to use them is so strange and flimsy that it is quite unbelievable that they would do so much. For this reason do not be discouraged. Be philosophical—just wait and watch. Nothing seems to happen, then after a few weeks things begin to blossom and unfold, and everything that you put into the mechanism and commanded it to perform will be there.

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A Comparison Of Cephalofacial Relationships*

Leonard A. Altemus, D.D.S., D.Sc.**

Orthodontists are greatly interested in the facial contours of their patients. This is especially true of the dental area. This paper is a report on the study of the cephalofacial relationship of a group of North American Negro children with normal occlusion of their teeth. This data should be useful to the practice of clinical orthodontics. An important part of treatment planning in clinical orthodontics is an understanding of what is normal. The theory of the "individual normal" has been recognized and accepted for many years. This theory emphasizes the infinite variety of faces which exist in any particular racial group within a range that can be called normal. If infinite variety exists within any single racial group, what must be the possibilities of individual differences between two or more racial groups? An important part of orthodontic treatment consists of changing facial features to improve them, especially in the dental area of the face. The modern orthodontist does not try to fit all of his patients into a single mold, in fact he has found that he cannot do so. Instead he seeks to reach the optimum esthetic result consistent with good function. We shall attempt to supply him with some of the knowledge necessary to assist in his decisions as to what is optimum for North American Negro children.

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The foundation of any study must rest on a firm knowledge of what is normal. Therefore our initial efforts shall be to determine what is normal for the heads and faces of these children. As this is a study by an orthodontist and primarily for the use of orthodontists, we have decided to use the teeth of these children as our criteria in the determination of normal. A mass survey was conducted in four junior and senior high schools of the District of Columbia. The purpose of this survey was to determine the frequency of the incidence of malocclusion in North American Negro children. The findings of this survey have been reported.[1] The children who were examined in the mass survey and found to have normal occlusion of their teeth were further examined at the College of Dentistry, Howard University. These examinations were as follows:

1. Heights and weights
2. Hand x-rays
3. Dental models
4. Cephalometric x-rays.

From the group of children with normal occlusion who were examined at the College of Dentistry, a further selection was made. Eighty children, forty boys and forty girls of Hellman's dental age IV A, i.e., their permanent dentitions were complete except for the third molars, were selected.[7] Their chronologic ages were from twelve to sixteen years. This gave a specific sample for further study and analysis

and is specific for dental age and occlusion of the teeth. Data are to be presented from a study of this selected group because it is felt that they are representative of a very stable period in the growth and development of the head and face. The dentitions of this selected group are also stable, i.e., they are beyond the variability seen during the period of the mixed dentition and ahead of the possible influences of the third molars on the occlusion.

The techniques of roentgenographic cephalometry as originated by Broadbent[2] and refined by many outstanding researchers have become one of the most useful methods of studying the head and face. The literature contains a vast amount of information utilizing these methods.

The cephalometric roentgenograms used in this study were taken in a Margolis cephalostat. Standard procedures of head positioning and exposure were used. The lateral or profile view alone was taken. The roentgenograms were traced and the analyses of Downs[5] and Sassouni[10] were used. Downs' analysis gives a series of measurements that can be used to appraise the relationships of the various parts of the facial skeleton and the relationships of the teeth to the facial skeleton. Sassouni's analysis gives a method of comparing the basic architecture of the head and face and the relative proportions of the various parts.

Presentation of Data

The data gathered during the progress of this study will be presented in the following manner: firstly, the information obtained from the study of the heads and faces of Negro children, henceforth to be referred to as the Howard group; secondly, the information especially selected as representative for the heads and faces of North American Caucasian children; thirdly, comparisons will be made of similar data gathered by similar methods on Negro children and other North American racial or ethnic groups.

Downs Analysis

The cephalometric x-rays of the selected normal group were traced in the standard manner and a Downs analysis done on each tracing. This analysis was chosen as representative for this area of the study because of its wide use and acceptance. The data gathered on the heads and faces of the eighty boys and girls of the Howard group are presented in Table I. The numerical values for the means, ranges and standard deviations are given. Vorhies and Adams[12] have devised a graphic means of presenting the values of Downs analysis and this is shown in Figure I. The means and ranges for Caucasian and Negro children are compared using these polygons.

Downs' analysis has been used so widely that comparisons will be made here of four North American racial or ethnic groups: Caucasian, Negro, Chinese and Japanese. These ethnic groups have been previously studied by

TABLE I. HOWARD GROUP
DOWNS ANALYSIS

Value	Mean	Range	S.D.
Skeletal Pattern			
Facial Plane	85.7	77 to 94.5	3.35
Convexity	9.7	23.5 to —5	4.80
A B Plane	—6.3	—12 to +5.5	2.68
Mandibular Plane	28.8	42.5 to 12	5.99
Y Axis	63.4	72 to 51.5	4.02
Dental Pattern			
Occlusal Plane	10.7	20.5 to —3	3.93
Interincisal	119.2	99.5 to 141.5	8 69
$\overline{1}$ to Occlusal Plane	27.3	39.5 to 12	5.66
$\overline{1}$ to Mandibular Plane	9.8	24.5 to —5.5	5.94
$\underline{1}$ to A-P (mm.)	10.4	19 to 3	2.75

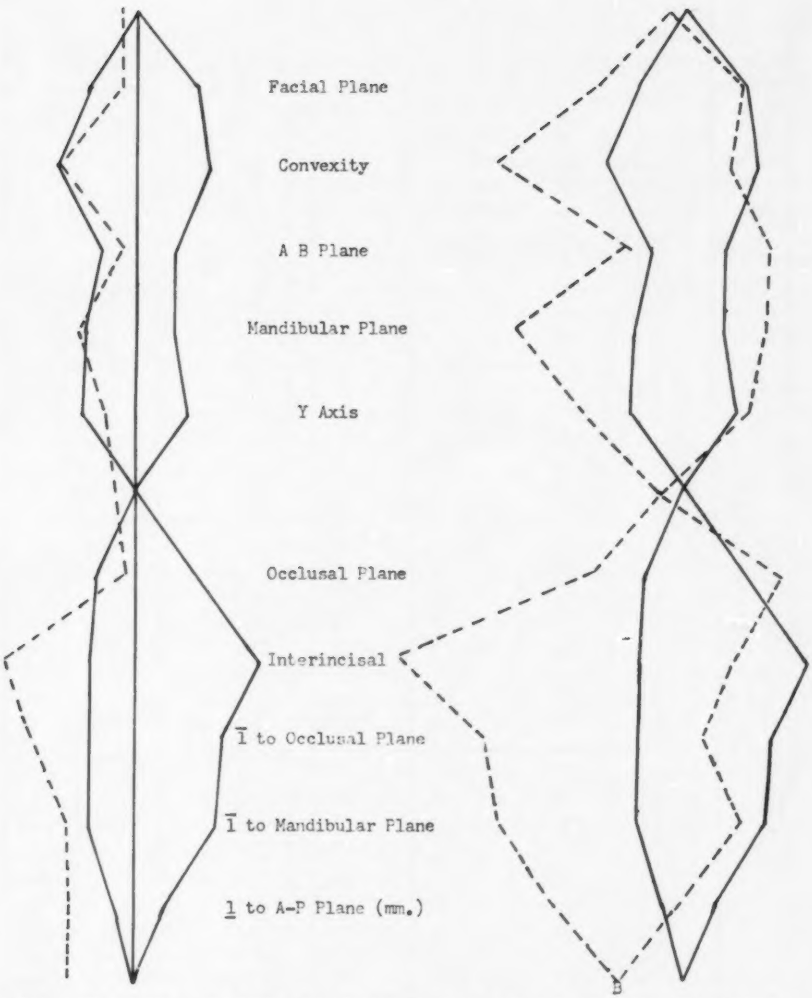

Fig.1 Left polygon — the broken line depicts the mean values for American Negro children on the Downs' analysis. Right polygon — the broken lines show the range for American Negro children.

TABLE II. COMPARISONS OF CEPHALOFACIAL RELATIONSHIPS OF VARIOUS AMERICAN RACIAL GROUPS (AFTER DOWNS)

SKELETAL PATTERN

	Facial Plane		Convexity		A B Plane		Mandibular Plane		Y Axis	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Caucasian (Downs)	87.8	82 to 95	0.0	+10 to -8.5	-4.6	0 to -9	21.9	17 to 28	59.4	53 to 66
Negro (Howard)	85.7	77 to 94.5	+9.7	+23.5 to -5	-6.3	+5.5 to -12	28.8	12 to 42.5	63.4	51.5 to 72
Negro (Cotton)	87.25	80 to 91	+9.6	+20 to +4	-7.7	-3 to -15	27.25	17 to 35	63.3	57 to 69
Chinese (Wong)	77.5	73 to 89	+7.5	+14 to +1.5	-5.7	-2 to -10	32.4	22 to 44	67.1	59 to 75
Japanese (Takano)	88.25	83 to 94	3.65	+12 to -1	-4.35	-1 to -7	24.3	14 to 33	62.1	56 to 68

DENTAL PATTERN

	Occlusal Plane		Interincisal		$\overline{1}$ to Occlusal		$\overline{1}$ to Mandibular		$\underline{1}$ to A-P (mm.)	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Caucasian (Downs)	9.3	1.5 to 14	135.4	130 to 150.5	14.5	3.5 to 20	+1.4	-8.5 to +7	2.7	-1 to +5
Negro (Howard)	+10.7	-3 to +20.5	119.2	99.5 to 141.5	27.3	12 to 39.5	+9.8	-5.5 to +24.5	10.4	3 to 19
Negro (Cotton)	11.8	+8 to +17	123.0	105 to 144	22.5	12 to 35	+6.6	-3.5 to +22	8.5	6 to 11
Chinese (Wong)	+16.9	+8 to +25	120.8	105 to 137	22.2	13 to 29	+7.8	0.0 to +18.0	7.6	3 to 12
Japanese (Takano)	9.65	2 to 19	126.4	114 to 152	21.5	8 to 31	+6.55	-6 to +13	6.6	2 to 10

the following individuals: Caucasian by Downs; Negro by Cotton; Chinese by Wong and Japanese by Takano. A comparison was made of the four studies listed above by Wylie[4] and we shall repeat some of his work. Table II lists the means and ranges for these four groups. We shall substitute the values obtained for the Howard group of North American Negro children for the values obtained by Cotton. We shall do this because we feel that our sample is more specific for this group. Cotton's group consisted of twenty Negroes of the San Francisco Bay area of California, ten males and ten females, ranging in age from eleven to thirty-four years. Cotton describes his sample as follows: "the occlusal relationships were not perfect but no real malocclusions were included." Because of the wide age span and small size of Cotton's sample as well as the uncertainty as to the occlusion of the teeth of his sample, it is felt that the Howard group will be more representative. Although the above statements are true, a close study of the two groups show them to be very similar. The mean values are presented side by side in Table II. Comparisons of these values show the following differences between the Cotton group and the Howard group: The skeletal patterns as seen in both groups are almost identical; a somewhat larger variation seems to exist between the dental patterns of the two groups, but the differences are not felt to be significant as they are all small, i.e., the mean values vary within a range of from 1° to 5° and approximately two millimeters in the measurement of the upper incisor to the A-P plane. When the differences in the size and makeup of the samples are considered, the over-all similarity is extremely close.

The skeletal pattern of the two groups, Negro and Caucasian, compare as follows. The mean values for the facial plane angle, a measure of the chin position, are similar 85.7°, for the Howard group and 87.8° for the Downs group; the ranges for these groups show the Howard group to be more retrusive and the protrusive extreme to be similar for both groups; the values are 77° to 94.5° for Howard and 82° to 95° for Downs. The mean values for the angle of convexity, a measure of the protrusiveness of the maxillary part of the face, indicate the Howard group to be more protrusive in this area. The mean values are 9.7° for the Howard group and 0° for the Downs group; the ranges give values of 23.5° to 5° for Howard and 10° to -8.5° for Downs. The mean values for the A B plane, a measure of the relationships of the denture bases to the profile and to each other, are similar for the two groups. The mean values are -6.3° for the Howard group and -4.6° for the Downs group; the ranges show values of 5.5° to -12° for Howard and 0° to -9 for Downs. The mean values for the mandibular plane angle, a measure of the relationship between the Frankfort plane and a tangent to the lower border of the mandible, demonstrate the Howard group has larger mandibular plane angles. The mean values are 28.8° for the Howard group and 21.9° for the Downs group; the ranges indicate values of 12° to 42.5° for Howard and 17° to 28° for Downs. The mean values for the angle for the Y axis, a measure of the direction of downward and forward growth, show the Howard group to have large Y axis angles. The mean values are 63.4° for the Howard group and 59.4° for the Downs group; the ranges give values of 51.5° to 72° for Howard and 53° to 66° for Downs.

The dental patterns of the two groups compare as now observed. The

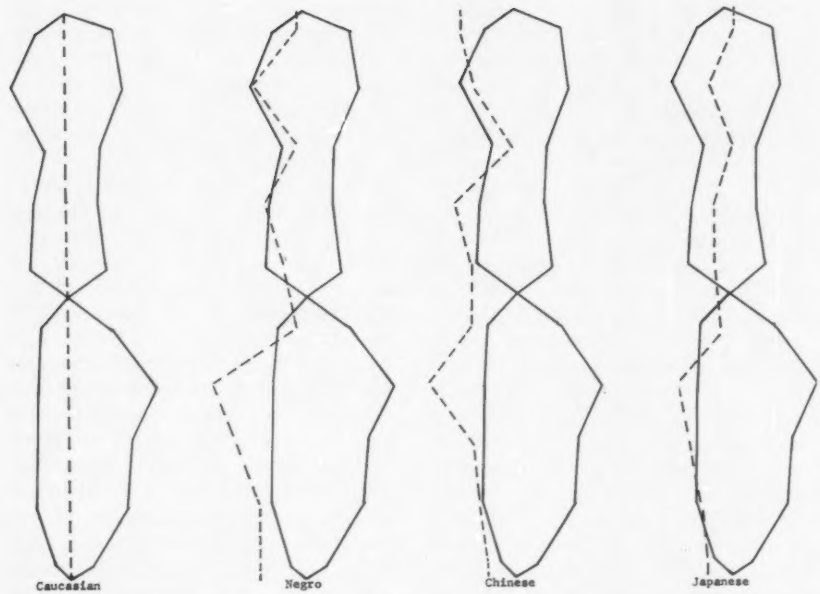

Fig. 2 Comparisons of four American racial groups on the Downs' analysis. The broken lines illustrate the means for each of the groups; the solid lines are the ranges for Caucasians.

mean values for the occlusal plane angle, a measure of the relative positions of the teeth in occlusion, are similar for the two groups, 10.7° for Howard and 9.3° for Downs; the ranges denote values of -3° to 20.5° for Howard and 1.5° to 14° for Downs. The mean values for the interincisal angle, a measure of the inclination of the upper to the lower teeth, show the Howard group to have more protusive teeth. The mean values are 119.2° for the Howard group and 135.4° for the Downs group; the ranges demonstrate values of 99.5° to 141.5° for Howard and 130° to 150.5° for Downs. The mean values for $\overline{1}$ to occlusal plane, the angles of the axial inclination of the lower incisors to the occlusal plane are larger for the Howard group than for the Downs group. The mean values are 27.3° for Howard and 14.5° for Downs; the ranges show values of 12° to 39.5 for the Howard group and 3.5° to 20° for the Downs group. The mean values for $\overline{1}$ to mandibular plane, the angles of the axial inclination of the mandibular incisors to the mandibular plane are larger for the Howard group. The mean values are -9.8° for the Howard group and 1.4° for the Downs group; the ranges give values of -5.5° to 24.5° for Howard and -8.5 to 7° for Downs. The mean values for $\underline{1}$ to A-P plane, a measure of the protrusiveness of the maxillary incisors expressed in millimeters, show the Howard group to be more protrusive. The mean values are 10.4 millimeters for the Howard group and 2.7 millimeters for the Downs group; the ranges indicate values of 3 to 19 millimeters for Howard and -1 to 5 millimeters for Downs.

Some of the data presented numerically in Table II and graphically in Figure 2 for four North American racial groups have been discussed in detail, specifically, the comparison of the data for Negroes and Caucasians using Downs' analysis. The data representing the other racial groups will not be given in as great detail, only the outstanding differences will be presented. A study of Table II and Figure 2 will show the following: The mean facial plane angle is similar for all of the groups except the Chinese. It is smaller for this group, which is an indication of a more receding chin. The mean angle of convexity is similar for Negroes and Chinese with Japanese nearly approaching the straightness of the Caucasian in the maxillary part of the face. The mean A-B plane angle, the relationship of the denture bases, is very similar for all groups. This observation had been made previously by Wylie, who further stated that a good relationship in this area was a prerequisite for normal occlusion of the teeth. The mean mandibular plane angle is smallest in the Caucasian group and largest in the Chinese group. This is to be expected for, as the facial plane angle decreases with a more posterior chin as has been previously noted for the Chinese group, the mandibular plane angle increases. The mean Y axis angle is greater in the Chinese group for the same reason as explained above — a more retrusive chin. Comparisons of the skeletal patterns of the four racial groups show considerable similarity in most of the areas measured.

The measurements to indicate the dental patterns are compared as follows. The mean occlusal plane angles are similar for Caucasians, Negroes and Japanese. The Chinese have the largest mean occlusal plane angles — this is expected because of the retrusiveness of their chins. The mean interincisal angles are relatively similar for Negroes and Chinese with the Japanese being somewhat closer to the straightness of the Caucasian. The mean axial inclination of the lower incisors to the occlusal plane show that the lower incisors are inclined more in Negroes with the inclination of Chinese and Japanese being similar and with considerably less inclination of lower incisors in Caucasians. The mean axial inclination of the lower incisors to the mandibular plane shows a somewhat different pattern than the inclination of the incisors to the occlusal plane. The mean angle with the mandibular plane is similar in Negroes, Chinese and Japanese and much less, or more nearly at right angles, for Caucasians. The final mean measurement in the dental area is the distance in millimeters of the upper incisor from the A-P plane. All of the groups except the Caucasian have upper incisors some distance forward of this plane. It is felt that the significant differences between the parts of the heads and faces of these groups that we have studied using Downs' analysis occur in the dental areas mostly, the exception being the retrusiveness of the chin in the Chinese group.

Sassouni Analysis

The cephalometric x-rays of the selected normal group were traced a second time and a Sassouni analysis done on each tracing. This was done to check the relationships of the various parts of the heads and faces to each other, i.e., the proportionality of these heads and faces. The data gathered from Sassouni's analysis will be presented somewhat differently than the data for the Downs analysis, namely, the Howard data will be presented, then comparisons made with data published by Sassouni,[10] and finally data will be

presented that were suggested by the results of the investigation. A full explanation will be given of this approach. Appreciation is hereby expressed to Dr. Sassouni for reviewing the data and offering helpful suggestions for its analysis. The anatomical landmarks, planes, arcs and angles used in our discussion of this analysis are presented in Figure 3.

Sassouni adds the concept of proportionality to that of a norm or standard. He defines a well-proportioned face as one which has the following proportional relationships: (1) the four facial planes meet at the same point *O*, (2) the skeletal profile is archial, (3) the anterior upper and lower facial heights are equal, (4) the posterior upper and lower facial heights are equal, (5) the corpus of the mandible is equal in size and position to the anterior cranial base, and (6) the palatosupraorbital and palatomandib-

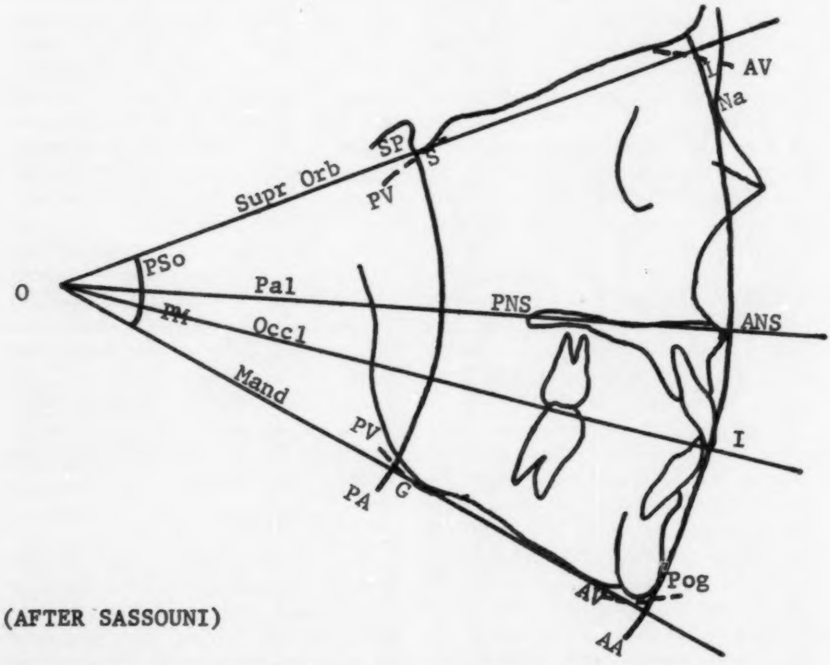

Fig. 3 Anatomical landmarks, planes, arcs, and angles used in this analysis:

Landmarks: O — center of the focal area where the four horizontal planes of the face converge; S — lowermost point on sella turcica; Sp — most posterior point on sella turcica; G — gonion; Pog — pogonion; I — incisal edge of upper central incisor; ANS — anterior nasal spine; PNS — posterior nasal spine; Na — nasion; L — the junction of the supraorbital plane and the anterior arc.

Planes: OSL — supraorbital or anterior cranial base plane; Pal — palatal plane; Occl — occlusal plane; Mand — mandibular plane.

Arcs: AA — anterior arc; PA — posterior arc; AV — anterior vertical arc; PV — posterior vertical arc.

Angles: PSo — palatal supraorbital angle; PM — palatal mandibular angle.

ular angles are equal. We shall present data relative to each of the above criteria for a well-proportioned face.

The four facial planes that should meet at a common point *0* are the anterior cranial base plane, the palatal plane, the occlusal plane and the mandibular plane. He thereby classifies faces with varying degrees or patterns of proportionality as follows: *Type I,* wherein the anterior cranial base plane does not meet the other three planes at common point *0*; *Type II,* wherein the palatal plane does not meet the other three planes at common point *0*; *Type III,* wherein the occlusal plane does not meet the other three planes at common point *0*; and *Type IV,* wherein the mandibular plane does not meet the other three planes at common point *0.* The above types are further classified into subdivisions depending on whether they pass above point *0,* subdivision A, or below point *0,* subdivision B. Table III presents the number of the Howard group found in each classification. The totals for Sassouni's group with normal occlusion of their teeth are also presented.

Before making any comparisons between the Howard and Sassouni data the following explanation is offered. Sassouni's sample consisted of 100 North American Caucasian children, 51 girls, 49 boys, 7 to 15 years of age; 50 children, 24 boys and 26 girls, had normal occlusion, and of this number 31 children, 15 boys and 16 girls, were of Hellman's dental age IV A: the remaining 19 children were in Hellman's dental ages III A, III B and III C. These children had been studied and their records were on file at the *Philadelphia Growth Center.* Sassouni combined his data for both sexes and all dental ages for his group with normal occlusion. The data for the Howard group will be compared with this combined data. It will be noticed that the totals in the Howard group equal eighty-nine whereas only eighty tracings were studied. Nine of the tracings had two possible classifications.

A study of Table III shows a wide diversification of facial patterns when classified in this manner. This diversification exists in both groups. Sassouni found 16 or 32% of his faces to be well-proportioned whereas only 3 or 3.4% of the Howard group were so classified. The largest classes for the Howard group are IA with 28 or 31.5%; IIA and IIB had 10 and 11 or 11.2% and 12.4% respectively; IIIB with 20 or 22.5% and IVA with 15 or 16.8%. The very high incidence of variability of the patterns or degrees of proportionality of the Howard group using this classification raises the question of its usefulness as a means for classifying facial patterns, i.e., the proportionality thereof, for Negro children.

We shall next present data from Sassouni's analysis relative to classification of the dentofacial skeletal profile. Sassouni bases his classification on the position of the anterior arc relative to the following points of reference on the profile; nasion, anterior nasal spine,

TABLE III. CLASSIFICATON OF CRANIOFACIAL TYPES

Facial Patterns	Howard No.	Howard %	Sassouni No.	Sassouni %
Well-proportioned	3	3.4	16	32
IA	28	31.5	4	8
IB	0	0.0	5	10
IIA	10	11.2	4	8
IIB	11	12.4	9	18
IIIA	1	1.1	3	6
IIIB	20	22.5	4	8
IVA	15	16.8	3	6
IVB	1	1.1	2	4
	89*		50	

*The total of 89 reflects the double classification of nine of the tracings.

upper incisor and pogonion. The skeletal profile types are called *Archial*: where the anterior arc passes through Na, ANS, upper incisor edge and pogonion (all of Sassouni's well-proportioned faces were archial); *Prearchial*: where ANS and pogonion are situated anterior to the anterior arc passing through Na; *Postarchial*: where ANS, upper incisor and pogonion are situated posterior to the anterior arch passing through Na; *Convex*: where ANS is situated anterior to the anterior arc and pogonion is either on the arc or posterior to it; *Concave*: where ANS is situated posterior to the anterior arc and pogonion is either on the arc or anterior to it. In studying the data gathered on the Howard group it was found that a large number, thirty-four in all, did not fit any of the above profile types. This matter was discussed with Dr. Sassouni who suggested the following additional classifications: *Mandibular protrusion*: where ANS is on the anterior arc and pogonion is anterior to this arc; *Mandibular retrusion*: where ANS is on the anterior arc and pogonion is posterior to this arc; *Archial except for teeth*: where the anterior arc passed through Na, ANS and pogonion (all of the points in the archial type profile except the edge of the upper incisor). In this type the teeth were always anterior to the anterior arc.

The totals of the dentofacial skeletal profile types for the Howard and Sassouni groups are presented in Table IV. An analysis of the data presented in Table IV shows that only 4 or 5% of the profiles in the Howard group were archial whereas 19 or 38% were archial in Sassouni's group. But, if we add the eleven who were archial except for their teeth in the Howard group, we have 15 or approximately 19%; we find 7 or 8.75% for the Howard group compared to 6 or 12% for

TABLE IV. CLASSIFICATION OF DENTOFACIAL SKELETAL PROFILE TYPES

	Howard No.	Howard %	Sassouni No.	Sassouni %
Archial	4	5.00	19	38
Archial except for Teeth*	11	13.75		
Prearchial	7	8.75	6	12
Postarchial	17	21.25	11	22
Convex	4	5.00	3	6
Concave	14	17.50	11	22
Mandibular Protrusion*	12	15.00		
Mandibular Retrusion*	11	13.75		
	80		50	

*Not observed in Sassouni series.

the Sassouni group having prearchial profile types; postarchial profile types found in 17 or 21.25% of the Howard group and 11 or 22% of the Sassouni group; convex profile types were disclosed in 4 or 5% of the Howard group and 3 or 6% of the Sassouni group; concave profile types were revealed in 14 or 17.5% of the Howard group and 11 or 22% of the Sassouni group; mandibular protrusion was found in 12 or 15% of the Howard group; mandibular retrusion was discovered in 11 or 13.75% of the Howard group. There are no comparative data for the Sassouni group for the last two types.

A study of Table IV shows a wide diversification of skeletal profile types when classified in this manner. Here again the usefulness of this classification as a means of defining a certain type of profile is questioned, but the value of relating the contributions of the various parts of the face to the total dentofacial skeletal profile is very helpful. It is felt that Sassouni did not intend that tracings as suggested by his analysis be made to compare one with the

TABLE V. DENTAL ANALYSIS
(Howard Group)

	No.	%
Equal	4	5.00
Plus	59	73.75
Minus	17	21.25
Total:	80	

other, but rather that there be found proportionality within each individual tracing. With this thought we wish to point out several observations relative to this classification — when applied to Negro children. The teeth protrude beyond the anterior arc in the great majority of these children. The number of children and the amount of the protrusion is shown in Table V. Those whose teeth fell on the arc were called *Equal,* only 4 or 5.0% were in this group; those whose teeth were anterior to the arc were said to be *Plus,* 59 or 73.75% were in this group; those whose teeth were posterior to the anterior arc were said to be *Minus,* 17 or 21.25% were in this group. The mean distance anterior of the arc was found to be 5.92 millimeters with a range from -3 to 14 millimeters. The standard deviation was 2.58 millimeters. Sassouni does not consider the positions of the anterior teeth except in the archial classification. The postarchial, concave, and mandibular retrusion profile types compose approximately 52% of the Howard group; these relationships tend to indicate retrusiveness in the faces of this group which have been reported as having protrusive faces; using this method there seemed to be as many retrusive chins as protrusive, 13.75% and 15% respectively. These indications will be further studied as the horizontal and vertical proportions of various parts of the face are related.

The vertical proportions of the face were studied using Sassouni's analysis and the data are presented in Table VI. The lower facial heights were said to be *Equal* when the upper facial heights, the distance between the cranial base plane and the palatal plane, were equal to the distances from the palatal plane to the mandibular plane; *Minus* when the lower face was smaller than the upper face; and *Plus* when the lower face was larger than the upper face. ANS and the anterior arc were used for the anterior proportions and PNS and the posterior arc were used for the posterior proportions. The anterior vertical proportions show that 6 or 7.5% of the Howard group had equal upper and lower anterior facial heights, whereas 14 or 28% of Sassouni's group had equal anterior facial heights; larger lower anterior facial heights were found in 69 or 86.25% of the Howard group and only 18 or 36% of the Sassouni group; smaller lower anterior facial heights were found in only 5 or 6.25% of the Howard group and 18 or 36% of the Sassouni group. The very obvious observation here is that the great majority of the Howard group had larger lower anterior facial heights than upper anterior facial heights and that the Sassouni group

TABLE VI. VERTICAL FACIAL PROPORTIONS

	Howard		Sassouni		Howard		Sassouni	
	No.	%	No.	%	No.	%	No.	%
Equal	6	7.50	14	28	15	18.75	23	46
Plus	69	86.25	18	36	25	31.25	9	18
Minus	5	6.25	18	36	40	50.00	18	36

was almost equally divided as to the relative sizes of their upper and lower facial heights. The question was raised as to how much larger were the lower facial heights than the upper in the Howard group. The tracings were measured and the mean difference was found to be 9.9 millimeters with a range from -3 to 29 millimeters. The standard deviation was 5.97 millimeters.

The posterior vertical proportions show that 15 or 18.75% of the Howard group had equal upper and lower posterior facial heights, whereas 23 or 46% of the Sassouni group had equal posterior facial heights; larger lower posterior facial heights were found in 25 or 31.25% of the Howard group and only 9 or 18% of the Sassouni group; smaller lower posterior facial heights were found in 40 or 50% of the Howard group and 18 or 36% of the Sassouni group. The Howard group had fewer faces with equal posterior facial heights; in fact, when the total number of equals and the larger lower posterior facial heights were combined, they exactly totaled the number whose lower posterior facial heights were smaller. Sassouni's group showed the greater number with equal posterior facial heights, but with an almost equal number having smaller lower posterior facial heights. The mean difference in the posterior facial heights for the Howard group, was 0.44 millimeters with a range from -12 to 14 millimeters. The standard deviation was 4.73 millimeters.

The horizontal craniofacial proporportions of the head and face were also studied using Sassouni's analysis. These data are presented in Table VII. The well-proportioned face, according to Sassouni, had a corpus of the mandible equal in size and position to the anterior cranial base. The corpus of the mandible, from pogonion to gonion, should fall between the anterior and posterior arcs (see Fig. 3). The Howard group had 3 or 3.75% whose mandibular corpal lengths and anterior cranial bases were equal; 73 or 91.25% whose mandibular corpal lengths were greater than their anterior cranial bases; 4 or 5% of the group had corpal lengths that were smaller. Although Sassouni mentions this proportionate relationship as a prerequisite for a well-proportioned face he does not present any data giving the numbers of his group with normal occlusion that had larger or smaller mandibular corpal lengths. He has had at least 14 or 28% of this group with all the other prerequisites so we assume that at least this number had equal cranial base and mandibular corpal lengths. The obvious factor here for the Howard group is that the corpal length of their mandibles is greater than their anterior cranial base lengths. The mean difference for this group is 7.8 millimeters with a range from -3 to 24 millimeters. The standard deviation is 4.56 millimeters.

TABLE VII. HORIZONTAL CRANIOFACIAL PROPORTIONS
(Howard Group)

	No.	%
Equal	3	3.75
Plus	73	91.25
Minus	4	5.00
Total:	80	

The vertical angular proportions, or the relationships between supraorbital or cranial base angle (PSo) and the palatal mandibular base angle (PM) were studied using Sassouni's analysis. These data were presented in Table VIII. That these angles be of equal size was one of the prerequisites for a well-proportioned face. The Howard group had one or 1.25% in whom the two angles were equal; 68 or 85% of

TABLE VIII. VERTICAL ANGULAR PROPORTIONS
(Howard Group)

	No.	%
Equal	1	1.25
Plus	68	85.00
Minus	11	13.75
Total	80	

the group had larger palatomandibular angles; 11 or 13.75% had smaller palatomandibular angles. We have no data from Sassouni for comparison. The palatomandibular angles are obviously larger for the great majority of the Howard group. The mean difference between these two angles for this group is 8.2° with a range from -13° to 25°. The standard deviation is 7.58°.

Upon studying the results of the data presented using Sassouni's analysis and by personal communication with Dr. Sassouni several suggestions were developed as to where and how these proportionate relationships of the heads and faces of Negro and Caucasian children differed and further if there were possible correlations between some of these differences. These suggestions were as follows: (1) correlate the differences between the lower and upper anterior facial heights to the differences between the palatosupraorbital (anterior cranial base angle) and the palatomandibular angles; (2) correlate the differences between the positions of the palatal plane to the foramen magnum to the differences between the upper and lower anterior facial heights; (3) make composite tracings of the Howard group and superimpose and compare these tracings directly with similar tracings of Caucasian children made by Dr. Sassouni at the *Philadelphia Growth Center*.

The differences between the palatosupraorbital and palatomandibular angles were correlated with the differences between the upper and lower anterior facial heights and are presented in Figure 4. This correlation diagram shows a very positive relationship between these two factors. The means of the differences were calculated as well as the coefficient of correlation. The mean of the differences between the two angles was 8.2°, the mean of the differences between the anterior facial heights was 9.9 millimeters. The coefficient of correlation (r) was found to be 0.71.

The differences between the positions of the palatal plane to the foramen magnum are correlated with the differences between the upper and lower anterior facial heights in Figure 5. This correlation diagram shows that there is practically no correlation between these two factors. The means of the differences were calculated as well as the coefficient of correlation. The mean of the differences of the positions of the palatal plane to the foramen magnum was 6.6 millimeters, the mean

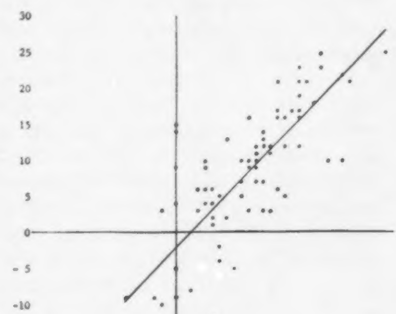

Fig. 4 Correlation diagram of the differences between the upper and lower anterior facial heights (X - axis) and the differences between the palatosupraorbital and palatomandibular angles (Y - axis) in eighty American Negro children with normal occlusion.

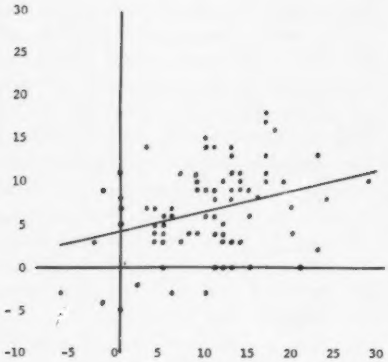

Fig. 5 Correlation diagram of the differences between the upper and lower anterior facial heights (X - axis) and the differences between the positions of the palatal plane and the foramen magnum (Y - axis) in eighty American Negro children with normal occlusion.

of the differences between the anterior facial heights was 9.9 millimeters. The coefficient of correlation (r) was found to be 0.0017.

Observation of the two correlation diagrams presented in Figures 4 and 5 shows that there is a positive correlation between the differences in the sizes of the palatosupraorbital and palatomandibular angles and the differences in the anterior facial heights, but no correlation between the differences in the distances of the palatal plane from the foramen magnum and the anterior facial heights. The palatomandibular angles have been found to be large in the Howard group as have the lower facial heights. It is felt that these factors play an important part in the particular configuration of this racial group.

The eighty cephalometric x-rays of the selected Howard group were studied again. This time they were separated into four groups as follows: 16 boys, 12 to 14 years of age; 16 girls, 12 to 14 years of age; 16 boys, 14 to 16 years of age; and 16 girls, 14 to 16 years of age. The four groups of x-rays were traced separately using the method employed by Krogman in craniometry and by Broadbent in roentgenographic cephalometry. The skeletal as well as the soft tissues were traced. This was done in the following manner: (1) We started with sixteen tracings in each age and sex group and superimposed them in pairs on the cranial base plane. (2) This gave a first average of eight tracings, which were then superimposed in pairs. (3) This gave a second average of four tracings which were again superimposed. (4) We now had a third average of two tracings which were superimposed. (5) This gave us a final average of one film which was the cumulative or composite tracing of the original sixteen. This final tracing was representative of a sex and age period and was accepted as a standard.

These standard tracings for each sex and age group were superimposed over similar standards for Caucasian children prepared by Sassouni at the *Philadelphia Growth Center* and these comparative tracings are presented in Figures 6 and 7. The cranial base plane was used as the plane of reference. The standards of the Caucasian children are represented by the broken lines, the standards of the Negro children by the solid lines. Observation of these tracings shows the over-all size of the heads and faces of the Negro children to be larger for each sex and age group; the teeth are more protrusive with larger interincisal angles; the lower facial heights are relatively larger than the upper facial heights as compared to Caucasian children; the palatal planes of boys and girls 12 to 14 years of age were inclined downward as well as that of the girls of 14 to 16 years of age; the mandibular base planes are surprisingly similar; the soft tissue profiles are similar in

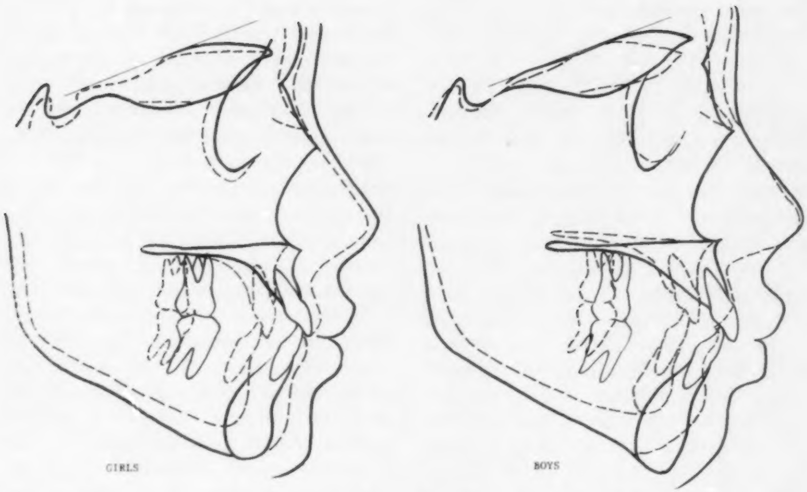

Fig. 6 Comparative standard tracing of American Negro and Caucasian children, twelve to fourteen years of age with normal occlusion. The broken lines are the Caucasian standards. The tracings are superimposed on a line tangent to the floor of the anterior cerebral fossa.

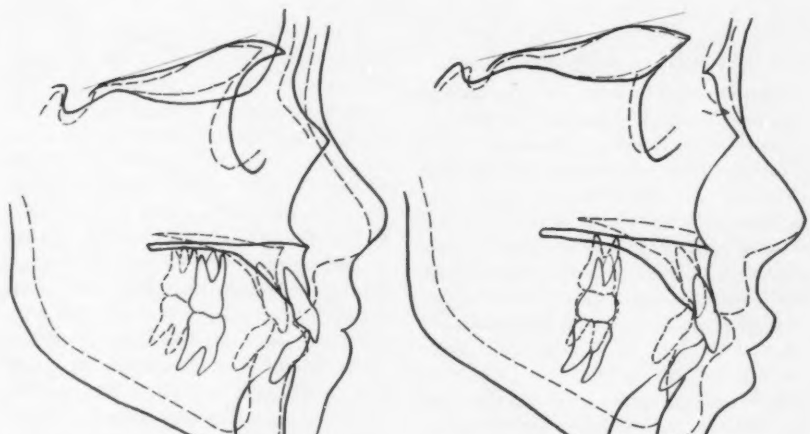

Fig. 7 Comparative standard tracings of American Negro and Caucasian children, fourteen to sixteen years of age with normal occlusion. The broken lines are the Caucasian standards. The tracings are superimposed on a line tangent to the floor of the anterior cerebral fossa.

the upper face but the areas of the lips are more protusive for the Negro children.

Summary

A sample of eighty Negro children, forty boys and forty girls, with normal dental occlusion was selected as a specific group for further study. The methods used in the study of this selected group were as follows: dental models, hand x-rays, heights and weights recorded on the Wetzel Grid, and cephalometric x-rays. The hand x-rays and Wetzel Grid were used to show that this selected group consisted of normal healthy children. The cephalometric x-rays of the selected Howard group were traced in the standard manner. The analyses of Downs and Sassouni were used. Composite tracings were also made according to the methods of Broadbent and Krogman. These composite tracings were made for the following four groups: boys, 12 to 14 years of age; girls, 12 to 14 years of age; boys, 14 to 16 years of age; and girls, 14 to 16 years of age.

Downs analysis data were compared for four North American racial groups: Caucasian, Negro, Japanese, and Chinese. The facial plane angles were similar for all groups except the Chinese whose chins were more retruded. The angles of convexity were similar for Negroes and Chinese with the Japanese approaching the straightness of the Caucasian in the maxillary part of the face. The A-B planes were similar for all the groups. The mandibular plane angles were smallest for Caucasians and Japanese with Negroes and Chinese being largest. The Y axis angles were similar for Negroes and Japanese with the largest angles being found in the Chinese group. Caucasians had the smallest Y axis angles. The skeletal patterns of these four racial groups show considerable similarity.

The dental patterns of the four racial groups were compared using a Downs analysis. The occlusal plane angles were similar for all the group except the Chinese who had larger angles, another indication of the retrusiveness of their chins. The interincisal angles were similar for Negroes and Chinese with the Japanese group being larger and the Caucasian group largest of all. The angle of the lower incisor to the occlusal plane was similar for Chinese and Japanese with Negroes having the largest angles and Caucasians the smallest. The angle of the lower incisor to the mandibular plane was similar for Negroes, Chinese and Japanese with Caucasians having smaller angles. The distance of the upper incisor in millimeters from the A-P plane was similar for Chinese and Japanese; Negroes were farthest from this plane with Caucasians being nearest.

A Sassouni analysis was done on each of the cephalometric tracings. These tracings were analysed by comparing the criteria for a well-proportioned face listed by Sassouni. The four facial planes, supraorbital, palatal, occlusal and mandibular, only met at a common point in approximately 3% of the children in the Howard group. The anterior lower facial heights were larger than the upper facial heights in approximately 86% of the Howard group. The posterior upper and lower facial heights were very variable with about as many of the lower posterior facial heights being of equal or larger size as there were that were smaller. The corpus of the mandible was larger than the anterior cranial base in approximately 92% of the Howard group. The palatomandibular angles were larger than the palatosupraorbital angles in 85% of the Howard group. The difference between the palatosupraorbital and palatomandibular

angles was found to be positively correlated with the difference between the upper and lower anterior facial heights. The difference between the position of the palatal plane to the foramen magnum and the differences between the anterior facial heights were found not to be correlated.

The composite tracings of the Howard group made according to the methods of Krogman and Broadbent were compared with similar tracings of Caucasian children, made by Sassouni at the *Philadelphia Growth Center.* The Howard group differed as follows: the heads and faces were larger for each age and sex; the teeth were more protrusive; the lower facial heights were relatively larger than the upper facial heights and the lips were more protrusive.

Conclusions:

1. There are definite and measurable differences in the configurations or facial patterns of the heads and faces of various North American racial groups, namely, Negro, Caucasian, Chinese and Japanese.

2. This study has shown that the mean over-all absolute size of the heads and faces of North American Negro children seemed to be larger than the the heads and faces of North American Caucasian children of the same age.

3. The degree and nature of the prognathism attributed to the Negro is a dental prognathism, i.e., the chin point as related to the facial plane is similar to that of the orthognathic face of the Caucasian.

4. The configuration or facial pattern of the Negro seems to be one wherein the lower facial height is larger than the upper facial height; the corpus of the mandible is larger than the anterior cranial base; the palatomandibular angle is larger than the palatosupraorbital angle and there is a positive correlation between the differences in the size of these angles and the differences between the anterior facial heights; and the teeth are anterior to the facial plane or Sassouni's anterior arc.

5. The skeletal patterns (in profile) of the Negro and Caucasian seem to be similar.

6. The differences in the craniofaciodental complex between Negroes, Caucasian and other racial groups have been pointed out and analysis of these differences seems to indicate that norms and standards of one racial group can not be used without modification for another racial group.

7. This study has emphasized the need for the presentation of new standards for Negroes, but it has also shown in measurable fashion that the range of normal variability within this group is very great, as it has been shown to be in other racial groups; because of this we wish to strongly emphasize the concept of the individual normal with modification indicated by racial attributes. The term Negro in North America is a sociological one;[10] we have been discussing anatomical and biological factors. Negro individuals will be found whose heads and faces are indistinguishable from members of other racial groups. A measure of judgment will be necessary in the utilization of the standards presented by this study.

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Mechanical Principles And Orthodontic Appliances*

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The true goal of any orthodontist should be to perform successful tooth movements and to constantly improve his ability to correct malocclusions. This is a purposely brutal simplification of the total task of the orthodontist. Of course, I know all of the fine distinctions about harmonizing facial contours and bony bases, aiding growth and development, correcting habits and muscular perversions and all the peripheral problems. And although I believe in the health benefits of orthodontics in some cases, the majority of patients are placed in our hands for one reason only, to align their teeth to improve their appearance.

Perhaps for too many years all orthodontic thought, study and teaching was focused on means and methods to move teeth but perhaps for too many recent years most orthodontic thought, study and teaching has been focused on the peripheral problems. Can you visualize one of us winning a research prize from any orthodontic group for developing a better technique to straighten teeth? For developing a better banding technique or bracket? For developing a better archwire or headgear? It is doubtful that such an entry would even be seriously considered.

Study of journals and texts reveals that there has always been a divergence of opinions as to the relative importance of the biological as opposed to the mechanical training of orthodontists. There probably always will be. My thesis is fairly simple: We can trace headfilms and measure them till infinity; conduct searching physical examinations involving blood, B.M.R., endocrine glands and what-not; perform diagnostic set-ups or employ gnathostatics or even study heredity and nutrition to help us reach a diagnosis and formulate a treatment plan but, once reached, we still have to correct the malocclusion satisfactorily.

This divergence of viewpoint was in evidence over fifty years ago when Dr. Angle and Dr. Case were the giants on the scene. At that time Dr. Angle quite properly was calling attention to the biological aspects and said,[1] "Much has been written upon the subject of orthodontia but mostly from the mechanical standpoint, and only very recently has it begun to receive that broad and thorough study which a science of such great importance demands, for its basic principles are grounded in the mysteries of embryology, histology and comparative anatomy, linked with art and physics." Case was saying,[2] "Those who hold to the theory that there are in the main, only three classes of irregularity which are characterized solely by their relations to normal occlusion, and which may be corrected with a few simple purchasable appliances, naturally take the ground that all training in the mechanical construction of regulating bands and appliances is a waste of valuable time, and of no practical advantage in practice."

*Presented before the Edward H. Angle Society of Orthodontia, Colorado Springs, October, 1959.

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As in all differences of opinion there was much of truth in both viewpoints. And those who knew these two men point out that Dr. Angle was truly an excellent mechanic and that Case was a fine student of biology. But now let us spend a few moments with mechanics and mechanical principles. Mechanics[3] is "that part of physical science which treats of the action of forces on bodies" and this is precisely what we do all day—apply forces to dentofacial structures to obtain certain reactions. Thus, simply pushing or pulling become mechanical acts and Newton long ago explained the results of this type of activity. But in man's dim historic past he invented certain mechanical devices through which his strength could be multiplied; the lever, the wheel, the inclined plane, the pulley, and the screw are the basic foundations upon which all his complex mechanisms rest.

Archeological studies show that man applied forces to move teeth in times long forgotten. Fauchard is generally credited with being the first to devise and use orthodontic arches around 1726. Plain bands were constructed several thousand years ago for prosthetic purposes but around 1848 Schange developed the clamp band for orthodontic use. He also was one of the first to make use of the elasticity in rubber to move teeth and to recognize the necessity for retention.

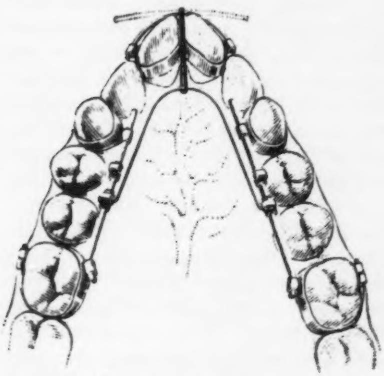
Delabarre introduced removable appliances in 1815 and Kneisel the headgear about 1836. Dwinelle developed the jackscrew in 1849. Magill is credited with being one of the first to use oxychloride of zinc cement to attach bands to the teeth about 1871.

While many men contributed extremely important improvements and are still doing so, within these basic ideas are encompassed nearly all orthodontic thought and action. From the basic idea of an ideal arch flows most of the wide stream of orthodontic effort. Think of it for a moment—whether the ideal arch is ivory, wood, metal, gold, vulcanite or steel and whether the teeth are tied to it or pushed by steel, brass, gold, silk, linen or rubber, the action is the same. If all teeth are to be retained it may be known as an expansion arch, if teeth are extracted it may be called something else. Still it is the form and structure to which the teeth are guided. The concept of attachment of the appliance by means of bands or cribs and clasps is equally fundamental to all appliance design. Elastic traction whether by rubber bands, elastic thread or tape is a single concept and since the headgear was introduced it has varied little. The use of inclined planes on plates or blocks or cribs is standard.

In 1900 Dr. Angle was discussing appliances and said,[4] "One surprising feature of the history is the frequency of the rediscovery of identical principles, their materialization differing only in minutiae of manufacture." We can repeat his statement today. Studying the orthodontic literature of the past provides a continuing source of amusement and amazement for the same old gadgets and methods keep cropping up proving that very few of us ever have a really original idea. To illustrate this let's look at a few of these old chestnuts.

The W shaped lingual arch has appeared and reappeared and usually is taught to students and given the name of a prominent orthodontist who uses it. In 1893 it was called the Angle device (Fig. 1). At the same time, the same principle in removable appliances was called the Coffin Spring. In my school it was called the Porter arch and in the West it is often called an Atkinson arch. In the early 1900's Case was using this headgear (Fig. 2).

FIG. 44.



Angle Device for Expansion.

Fig. 1 From Guilford, 1893.

FIG. 135.

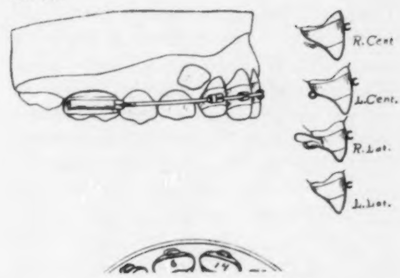


Fig. 4 From Case, 1908.

Is this reminiscent of our modern high pull gears? Does this look like a face bow known by another name today (Fig. 3)? It has been said that the McCoy open tube gave Dr. Angle the idea for the edgewise bracket—this is doubtful for Case was using such bands in 1900 (Fig. 4) and we know that Case and Angle knew each other's work. Just incidentally, Dr. Angle was using sectional arches on extraction cases in 1890 (Fig. 5).

Now the proper response to this information may well be so what? Just this, too many orthodontists today either don't know or have conveniently forgotten the basic mechanical prin-

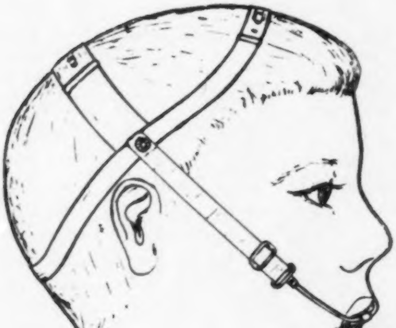


Fig. 2 From Case, 1908.

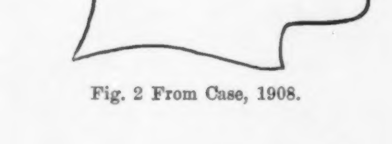
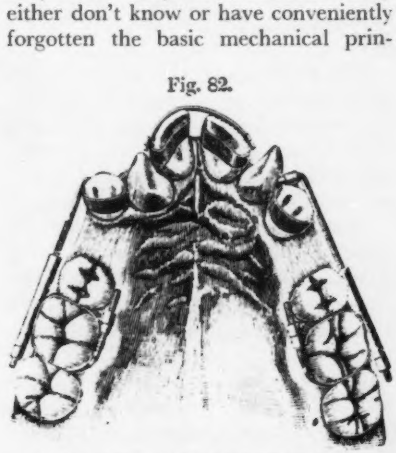


Fig. 3 From Case, 1908.

Fig. 82.



Backward Movement and Rotation. (Angle.)

Fig. 5 From Guilford, 1893.

ciples involved in all orthodontic appliances and consequently no longer apply them. We all learned early in school that to each action there is an opposite and equal reaction, but we also were taught that a very small force applied through a sufficiently long lever could produce tremendous resultant changes. We learned that the inclined plane, the lever, the pulley and wheel, the axle, the screw and the wedge were the foundations upon which all machines were built.

In recent years there almost seems to be a campaign to deprecate the skill of the mechanic in dentistry. The chairman of the orthodontic department at one of our universities recently said,[5] "The effective use of good appliances is as essential to orthodontics as breathing is to living *but* it is a means to an end, not an end in itself, and our real problems do not lie in that area." Many more of our professors feel the same way. There has also been a good deal of public hand wringing about our professional problems with transfer cases—if all orthodontists were following sound mechanical principles most of these problems simply would not exist.

The average orthodontic curriculum assumes that the student thoroughly understands mechanical principles and plunges into the growth and development as though the successful movement of teeth was a byproduct of our efforts. The student is thoroughly impressed with the importance of being able to trace a headfilm and compare it with somebody's analysis and come up with a treatment plan without being properly impressed with the fundamental necessity for controlling tooth movement with the tools at hand—the orthodontic appliance. As a result, such a basic guide as Newton's first law of motion is frequently forgotten. For example, completely ignoring the clinical knowledge of the strength of the cuspids, if we assume equal and opposite action to be true, we know that at least more teeth must be incorporated in the so-called anchor unit than in the unit to be moved. But time and again we see practitioners pitting the six anterior teeth against two bicuspids and two molars in extraction cases and, even worse, pulling simultaneously against the weakened anchorage with Class II elastics. It is not necessary to adopt Tweed's ideas of anchorage preparation to realize that the mandibular buccal units will fail and move mesially producing an eventual failure in an otherwise well-conceived extraction case. Many years ago Stanton worked out the resistance offered by different teeth and even this bit of assistance is largely lost today.

Think now—what was wrong with the last transfer case about which you were unhappy? To begin with, I suspect that even if it was a so-called edgewise case that it was not completely banded to really take advantage of this beautiful appliance. Every appliance has good points but when the total appliance is not in place, how can it be fully utilized? We see edgewise cases with no bands on bicuspids or second molars, twin arch cases with no anterior bands, headgear appliances with dead coil springs—how can they work?

We see edgewise cases fully banded with neither eyelets, Lewis levers nor twin brackets—how can one control rotations? I would be ashamed to call myself an orthodontist if I couldn't handle several appliances but what if the total appliance is not even completely assembled or constructed? No, I don't believe that any amount of pious preaching about public opinion will solve our transfer problems. We need to look within ourselves to see if, in our eagerness to hasten matters

and handle more cases, we are leaving out essential mechanical parts of this appliance with which we propose to correct a malocclusion by mechanical means.

More emphasis should be placed in our meetings and in teaching on the basic mechanics of tooth movement, on the value and use of levers and leverage and the other means of mechanical advantage. Every appliance employing a band and one archwire utilizes these principles. It is true that the functional jaw orthopedics practiced in Europe do not, but not many of us as yet have adopted those methods.

The fine orthodontic results seen across America today are the result of superior technical procedures developed by outstanding mechanics in our profession. The literature of recent years is replete with learned papers explaining why Tweed gets the results he does or why the Kloehn approach elicits its response. One can find hundreds of such words of explanation and records but no biological research which has led to a methodology which we could follow.

In fact, the efforts to reduce biological research to clinical practice is currently raising a dangerous problem. There is a strong tendency today for clinicians to use the cephalometric headfilm as a direct and often principal diagnostic tool. The film is traced, the angles and lines measured and carefully charted and compared with one of several popular standards. Then this comparison alone is frequently used as a final decision as to method and rationale of treatment. Time and again it has been shown that biological and physiological norms are extremely difficult to establish and that the best are only useful as guides or aids in all parts of medicine. Perhaps in time the headfilm could be the sole diagnostic tool but today it should be used with judgment as one of the battery of tests to determine proper diagnosis. Study of the face, the total head, the relationship of the parts of the face and, by all means, the parents and other members of the family as well as models, photos and x-rays to determine the best approach to treatment is essential. Frequently such careful examination will show that the headfilm alone gives an erroneous and misleading answer but when used in conjunction with other guides will give completely reliable information.

Now a word about some fundamental actions and reactions and their continuous use in practice. Many texts show the classic illustration which demonstrates the pull of a Class II elastic over the end of a lower archwire, elevating the distal of the last banded tooth and tending to tip its roots distally. Yet good mechanics show this fault can be largely overcome by proper placement of a hook on the mesiogingival corner of the band. The old timers knew a lever could really rotate a tooth and Paul Lewis has brought the lever up to date with his bracket.

One could spend an hour showing old headgears and their modern duplicates. The laminated arches of today are a sound application of a well-known principle.

So what's new? What can be done to improve our mechanical methods? I predict that the next great step in orthodontics will be a proper adhesive to free us from the tedium of band construction. Brackets or other attachments will be placed directly on the teeth. Modern technology has produced a wide new spectrum of adhesives including the epoxy resins which have tremendous strength under all conditions. Some are dangerous in the mouth while others are simply too strong. In other words, once the bracket or attachment is fastened to the tooth,

there is no easy method of removal short of grinding it off. Unquestionably these technical problems can be solved. Surely we can produce an adhesive and a solvent which would adhere rapidly to dental enamel and metal, be insoluble in the mouth yet readily soluble by proper solvents. The fact of the matter is that all of our present dental cements are cohesive in nature and not adhesive at all. They principally act to fill the space between band and tooth, or between inlay and tooth—not to actively perform a fastening or sticking function. Development of an adhesive material which would be safe to use in the mouth, insoluble by saliva, soluble by solvents and with tremendous strength would not only revolutionize orthodontics but the whole field of operative and restorative dentistry as well. Believe me—it's overdue.

Since man first ligated teeth with grassline there have been few improvements in the fastening department. The pin and tube appliance was one variation; the lock pins on the ribbon arch were another which was copied in the Universal appliance.

The McCoy open tube is a variation but the present edgewise appliance takes us right back to the old tying procedure. The most effective closure on an orthodontic appliance today is seen in the Johnson lock and cap. Yet this could be greatly improved. The wide use of staplers in American industry today could show us the way. Why not a staple to fasten our archwires in place such as this (Fig. 6)? With all of our fine prefabricated appliances and attachments, we are still held back at the point of delivery by an old tedious method. Perhaps one of us will devise a completely new bracket and a method of closure.

Elgiloy is a step toward better alloy materials for arches and wires but new and better materials will come. The

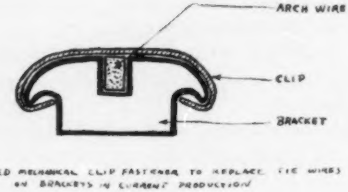


Fig. 6

billions expended on metallurgical research for rocketry has resulted in fantastic strides but these advances are simply not available to us because dentistry does not have the organization within industrial groups to exploit these discoveries. While large corporations spend millions to produce a new antibiotic or other medical product, the dental industry rarely, if ever, develops new products. Usually some self-sacrificing practitioner brings forth the new method or material to have it produced and sold by the dental manufacturers. And the manufacturers of dental products cannot be blamed for their market is too small to warrant expenditures of large sums on research and development. The returns would not justify the price to the stockholders. If a fraction of the biological research in orthodontics were directed toward our mechanical problems, progress could be greatly hastened. Unfortunately, far too little university or other research funds find their way from the natural sciences to the physical sciences where dentistry is concerned.

I would like at this time to pay tribute to all those who are struggling to change biology through mechanics. It has been the intent of this paper to re-emphasize the purely mechanical part of orthodontics. The manual ability of the orthodontist is of the greatest importance. The profession of dentistry and the specialty of orthodontics have both enjoyed a meteoric rise in twentieth century America and the high acceptance accorded to Amer-

ican dentists throughout the world is based on their ability to do the job superlatively. To me this is a part of the unique mechanical talent so widely exhibited in all phases of American life. This phase of practice should never be subordinated to the perhaps more esoteric portions which are, after all, only curtain raisers to the main event — successful tooth improvement.

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DISCUSSION

Dr. R. H. W. Strang

To those of us who claim to be only clinical orthodontists, Dr. Parker's paper has an appeal that probably is more intimate than may be the case with others. Personally, I think it to be a very timely presentation. It certainly recalls memories of errors made in my own practice and errors that have been seen in referred cases.

Dr. Parker emphasizes the need for employing all available auxiliaries for case study previous to treatment. He then calls attention to the fact that the data thus obtained tells us only what has led up to the malocclusion and what has to be done in treatment but offers no information relative to how the corrective procedures are to be performed. Certainly all this knowledge without a thorough understanding of mechanical principles is wasted as far as the welfare of the patient is concerned.

However, we must also bear in mind that the most expert mechanic, even though he be a graduate of the best engineering course in the whole United States, would be a very dangerous orthodontist if he did not have the biologic foundation so essential to our special field of practice. Certainly the "what man" without the "how" and the "how man" without the "what" are equally unbalanced.

Force is an ever present phenomenon in the anatomical area in which we work and is the agent that we use in our corrective procedures. We certainly cannot learn too much about its presence in Nature's hands or in its use by *our* hands and brains.

Dr. Parker's historical review of appliances was interesting and enlightening. Simplicity of design in appliances was constantly preached by Dr. Angle and, of course, brackets cemented to the teeth would be a simplification. However, they would only be the handles for attaching the force application and would not reduce the necessity for a complete understanding of anchorage problems and cellular response to applied force.

This is not a paper that is open to constructive or adverse criticism but rather is one that is timely and commendable. Furthermore, there is one sentence that bears repeating in this discussion and I shall make it the final one of my review. Here it is: —

"We need to look within ourselves to see if, in our eagerness to hasten matters and handle more cases, we are leaving out essential mechanical parts of this appliance with which we propose to correct a malocclusion by mechanical means." And, I might add, there is the ever-present danger of omitting the finishing details in tooth adjustments that mean so much in stabilizing the final result.

Short, Intensive Use Of Tooth Positioners And An Appraisal Of The Results

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Introduction

This project, as the title suggests, is a study to determine the resultant quantitative changes evocable in finishing an orthodontic case with a rubber tooth positioner. Further, the intention was to have the patients wear the appliance for no more than a six week period and less if possible. During this time it was emphasized that the patients follow instructions in wearing the positioners as much as possible.

Through trial and error in the author's previous experience it was found that he achieved better orthodontic results with the short, intensive procedure. Longer periods brought more undesirable effects and even some failures that required partial retreatment.

It will not be necessary to burden the reader with the definition, explanation and history of the tooth positioning appliance as it has been familiar to most orthodontists since 1944 when Kesling[1] introduced the modern tooth positioner.

The objectives of this study are:

1. To determine the quantitative extent of the changes that take place, if any, during this short period of treatment.
2. To see if there is any tendency toward a change that might be objectively described as attributable to the tooth positioner.
3. And if so, this preliminary appraisal could lead to a more extensive statistical evaluation.

Method and Observations

The knowledge that cooperation in wearing the appliance would be forthcoming from the patients was made possible by having an interview with each prospective case a few appointments prior to the time they would be ready for the positioner. The extent of cooperation that could be expected was evaluated by discussing with the patient all the advantages and disadvantages of this type of treatment at successive appointments. If it was felt that the patient would average at least better than sixteen hours out of possible twenty-four, the case was selected for this study. The type of occlusion, difficulty of case, and length of treatment were not factors in the selection of these cases. The only factor considered was the element of cooperation.

Ten cases were chosen for this study. Models and head plates were taken at the time the appliances were removed and models and head plates were taken immediately after tooth positioner treatment was terminated. The mean length of this phase of treatment was 31.8 days.

The cooperation that ensued was very gratifying with the patients wearing the appliance an average of 17.3 hours per day. The minimum time the positioner was worn amounted to an average of fourteen hours per day. The maximum effort put forth by a patient amounted to twenty-one hours per day.

Presented before the Midwestern Component of the Angle Society, Chicago, January 1960.

As a matter of common usage and to save space and time, I will refer to the tooth positioner henceforth as T.P.

The T.P. procedure was initiated by the removal of all the bands and associated appliance. Immediately two upper and two lower alginate impressions were taken. These were immediately poured into models. One set was mailed to a laboratory with instructions to return the wax setup for changes and approval before making the appliance. The second set of models was trimmed to serve as the before T.P. models. A head plate was taken within twenty-four hours to serve as the before T.P. head plate. In addition, a duplicate upper model was poured. On this model an upper acrylic retainer was constructed and seated the following day. This procedure was instituted to minimize any undesirable movement of the teeth during the time necessary to construct the positioner.

After receiving the wax setup from the laboratory the necessary changes were made and the models returned for processing. In the final adjustment of the wax setup it was found beneficial to slightly equilibrate or relieve the plaster teeth to refine the occlusion. Subsequently, at the time of T. P. delivery the same changes were duplicated by equilibrating the denture of the patient. This procedure can be justified in that abnormal occlusions do not ordinarily exhibit the normal abrasion facets.

The first post-delivery appointment was in one week. All subsequent appointments were at one week intervals until it was felt that the most desirable objectives had been accomplished. These appointments were spent in checking the results and making refinements by removing rubber in selected locations. In addition, an effort was made to keep up the morale of the patients as this procedure plays havoc with their social schedule.

At the appointment when the T.P. procedure was terminated, a set of final impressions as well as impressions needed for conventional retainers were taken. Again, final head plates were taken within twenty-four hours.

The twenty sets of models were then studied. The before and after measurements in millimeters were recorded. The following list records the observations noted or measured in millimeters as taken from the models:

1. Maxillary and mandibular intracuspid expansion or contraction.
2. Maxillary and mandibular intramolar (first) expansion or contraction.
3. Torque changes.
4. Space closure.
5. Crossbite or outlocked relation.
6. Rotational changes.
7. Overbite change.

The recordings of items 1 and 2 may be seen in Table I.

The before and after head plates were then traced and studied. In order to evaluate the anteroposterior changes a base plane was established by scribing a line from nasion through A point and extending beyond the border of the mandible. This line provided one line

TABLE I

Medial-lateral changes

Case No.	Intracuspid Max.	Intracuspid Mand.	Intramolar Max.	Intramolar Mand.
7	—2.6 mm	—.5 mm	—2.8 mm	.7 mm
131	—1.5	+.5	1.5	.5
183	—1.5	—1.0	—.5	—.5
185	.5	—1.0	—.5	.5
195	—3.0	—1.5	—2.0	.5
205	—1.0	—1.8	—1.8	.0
208	—1.8	.9	—.5	1.5
211	—1.3	+.5	.0	—1.0
217	—1.5	—.5	—.5	1.0
227	—2.0	—1.5	—1.5	—1.0

TABLE II

Lateral Angular Changes

Case No.	$\underline{/1}$ To $\overline{/1}$ B	A	$\underline{/1}$ To NA B	A	$\overline{/1}$ To NA B	A	Mand. - NA B	A	Occl. - NA B	A
7	150.7	141.1	1.4	12.4	28.0	26.5	54.5	55.1	73.8	75.9
131	120.0	128.8	33.5	30.0	27.0	21.8	75.4	75.5	85.5	87.5
183	133.9	140.0	17.8	12.0	29.0	28.2	169.4	169.3	76.5	77.2
185	136.0	136.0	16.0	16.6	28.5	27.8	68.5	68.1	82.7	82.5
195	128.5	126.5	12.7	12.8	38.8	41.0	63.6	61.9	78.3	80.5
205	126.3	127.2	19.5	22.7	34.1	30.7	76.6	77.7	83.8	82.9
208	137.0	137.8	19.5	19.2	23.8	23.1	73.0	72.7	86.8	86.3
211	134.0	140.3	14.7	12.1	31.6	28.0	69.8	70.0	84.2	83.9
217	135.8	136.8	10.0	8.4	35.0	35.1	62.8	62.3	78.0	78.0
227	135.9	134.2	11.8	14.3	32.0	29.3	59.6	59.8	79.0	72.5

B, before tooth positioner. A, after positioner.

of an angle, with the anterior teeth, occlusal plane and mandibular plane providing the other necessary lines. This line will be referred to as NA. The final tracing was superimposed over the first, and the original NA drawn on the second tracing.

The following measurements in degrees were taken and recorded as seen in Table II.

1. Mandibular Plane — NA
2. Occlusal Plane — NA
3. $\underline{/1}$ — NA
4. $\overline{/1}$ — NA
5. $\underline{/1}$ to $\overline{/1}$

The hard tissue changes on the head plates were measured linearly using millimeters as the unit of measurement. These measurements included both anteroposterior and vertical changes.

The anteroposterior changes may be seen in Table III and the vertical changes may be seen in Table IV.

After the head plate readings were recorded a cross relation study between all the findings was taken in each individual case in order to attempt to find out if related readings substantiated each other.

Interpretations

When this study was undertaken, it was understood that three factors would necessarily make this appraisal subjective regardless of the consistency of any particular readings. The first factor is that this work embraces too few cases to lend any statistical stature. However, the study was initiated as a pilot project to see in what direction an enlarged analysis might bear fruit. Secondly, the short period of treatment would inherently make the changes small and thus more prone to error. As the author pointed out earlier, in his hands the longer period of treatment induced undesirable effects such as an alarming increase in the overbite. The third factor is the recognition that if a T.P. had not been worn many of these changes would naturally take place, although probably not in the direction, or to the extent as with a T.P. This factor could only be negated with a control study.

The medial-lateral readings of the models verified that the T.P. dimensions, as would be expected, closely approximated the final results. With the exception that those cases which exhibited the most severe original prob-

TABLE III

Anteroposterior Linear Changes

Case No.	$\underline{/1}$	Pogonion	$\overline{/1}$ to Mand.
7	3.8 A	.3 A	.2 P
131	.3 A	2.0 A	3.0 P
183	.5 P	.0	.0
185	1.0 P	.5 P	.0
195	.5	.5 P	.0
205	1.0 A	1.5 A	.5 P
208	.0	.0	.2 P
211	2.0 P	1.0 P	1.0 P
217	.0	1.2 P	.0
227	.3	.0	.3 P

A, anterior; P, posterior.

lems did not uniformly correct satisfactorily. This could very likely be remedied by employing more careful mechanics prior to T.P. introduction. The maximum change was a 3 mm reduction in maxillary intracuspid distance. The greatest expansion was .9 mm in the mandibular intracuspid distance.

In retrospect, there is a tendency at times to disregard the time factor by making setups to an ideal image.

TABLE IV

Vertical Linear Changes

Case No.	Max. Incisors to C	Incisors to M	Max. Molars to C	Molars to M
7	1.9	.2	2.0	—1.0
131	1.5	1.5	1.0	.0
183	1.7	.0	1.2	.5
185	.3	—1.0	.4	—1.4
195	3.1	2.0	4.0	.0
205	.3	1.0	.0	.0
208	—1.2	.5	—1.8	.5
211	.5	.0	.5	.5
217	.7	.0	2.2	.0
227	—1.3	.0	.0	.5

Changes are in mm of eruption, minus signs indicate depression. C, cranium; M, mandible.

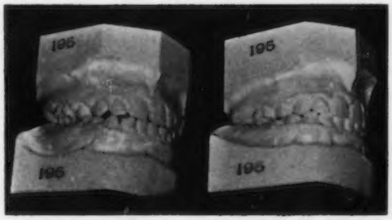

Fig. 1. After seven weeks of treatment the maxillary right molar, although improved, has not completed its movement.

A better appreciation of this factor may bring to realization a better end result by constructing an overcompensated wax setup. This need is illustrated by the results seen in Figure 1. The original setup on this case (No. 195) was ideal, but it was necessary to terminate treatment in forty-eight days because the overbite was becoming excessive yet the buccal segments had not contracted as much as would be desired. Incidentally, this was the longest period of T.P. treatment experienced, lasting seven weeks; this case also made the author appreciate the limitation of a T.P. The rubber appliance is not a substitute for good mechanical treatment. As mentioned earlier, another possible solution for the dilemma presented by the previous case would be to make the maxillary wax setup with less intrasegmental width for the upper right first molar, and relieved on the lingual by adding wax on the offending tooth. Furthermore, it might facilitate more desirable results by relieving all T.P.'s with a uniform coating of wax on all the tooth surfaces in which the movement is directed. This would diminish resistance.

An astute understanding of the time element as related to the mechanics acknowledges that time works for the betterment of some movements but is often deleterious to others. This statement may be as aptly applied to T.P.'s as to other appliances. We need to

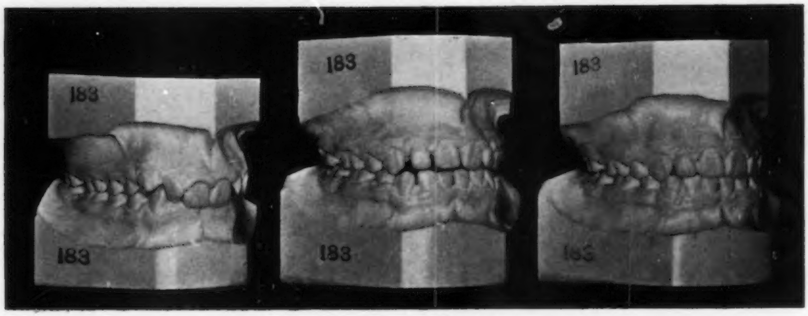

Fig. 2. Case No. 183.

give this possibility more thought in making wax setups.

Although the desired torque of anterior teeth to some degree does take place, this study revealed that most axial changes were accomplished by a tipping action. In case no. 183, it was noted that the wax setup reflected a torque action for the centrals; and further, observations of the posttreatment model revealed some improvement in this relation (Fig. 2). The head plate refuted this observation by revealing that actually reverse movement took place with the roots moving anteriorly 5.8° to NA. The changes in the lower anterior teeth as well as the occlusal planes often give rise to this illusion.

The anteroposterior linear changes demonstrated a decided variance in moving either direction of about the same latitude. In reviewing these changes it is apparent that the T.P. elicits about as varied a directional response as random chance would permit. In case no. 7, the maxillary centrals were inlocked posterior to the mandibular incisors. The entire correction was a tipping action with the maxillary centrals moving forward 3.8 mm (Fig. 3). This movement represented the maximum anterior movement. The greatest posterior movement was seen in case no. 131 (Fig. 4). The mandibular incisors in this case moved three mm posterior, as related to the mandible. This particular case originally had shown evidence of a strong mentalis reflection. At the conclusion of T.P. treatment there existed a slight overjet.

The lateral angular changes corroborated the linear measurements taken. These measurements were taken primarily to substantiate the linear recordings and secondly, to study the axial changes of the incisors in evaluating intended torque changes. Although it was not intended in T.P. treatment to bring the apices of the maxillary incisors forward, it was demonstrated that this occurred in three of the ten cases. Lingual root torque did occur in two cases, but only

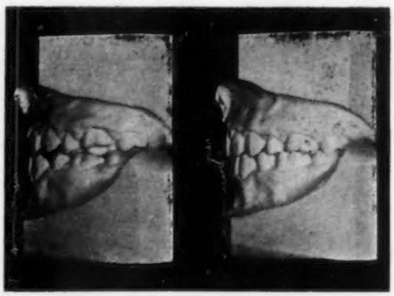

Fig. 3. Before and after TP treatment of case No. 7. Note correction of inlocked maxillary centrals.

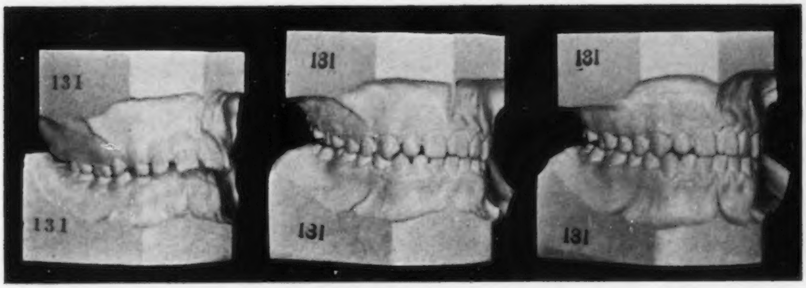

Fig. 4. Case No. 131.

to minor degree.

The same interpretation is taken by the author in regard to the vertical linear changes as was assumed in respect to the anteroposterior changes, that is, about anything that might be imagined as far as directional change was observed. If anything could be said, it is that the majority of the cases responded by eruption of the maxillary and mandibular incisors, as well as the maxillary molars. This eruption pattern was of a magnitude of less than two mm on the average, the only exception being the maxillary molars in case no. 195 (Fig. 1). Originally they were in supraocclusion a considerable extent before the T.P. was introduced. The eruption of most of the teeth could, in part, be attributable in the molar region to this lack of initial close interdigitation. As these teeth settled into occlusion, the way was paved for the anterior teeth to close or, in effect, to increase the overbite. This would be particularly true with the intra-arch space filled with rubber in a parallel manner.

A considerable amount of time has been spent studying eruption and depression of anterior and posterior teeth, and any resultant mandibular opening as related to the intra-arch rubber of the T.P. The author fails to see any definite evidence that by altering the opening of the wax setup we are able to foresee predictable results, such as the depression of specific teeth. Very likely it would be difficult to foretell accurately such movement; the related factors are too complex to be reduced to a simple solution. Among the conditions that would influence these changes are: the original orthodontic problem, movements that have taken place during treatment, encroachment of the freeway space, and the mandibular functional path.

The T.P. is an excellent device for finishing a mechanically treated orthodontic case. It primarily facilitates close interdigitation that would ordinarily be time consuming in some hands. Secondly, in those cases where success might hinge upon the interlocking of dental units, it is a good insurance policy.

In conclusion, I submit that the original problem and treatment procedure that preceded the tooth positioner treatment, as well as the functional dynamics, are of the most important magnitude in judging what the tooth positioner will, or will not do.

Summary

A study was made of ten mechanically treated orthodontic cases in which the finishing was accomplished with a rubber tooth positioner. The tooth positioner was worn intensively for a period of six weeks or less.

The analysis was undertaken in an attempt to determine the quantitative extent of the changes that take place, if any, during a short period of wearing a positioner, secondly, to see if a definitive trend was established that may be attributed in part to a tooth positioner, and finally, if a trend of sufficient magnitude was demonstrated, it could likely encourage further research of a statistical nature.

The tooth positioners were worn an average of 17.3 hours per calendar day and extended through periods of at least 19 days in two cases. The lengthiest duration was 48 days with an average mean of 31.8 days for all the cases.

Models and head plates were taken before and after, and various methods were used utilizing both angular and linear measurements to determine the changes that took place.

Conclusions

1. A tooth positioner does not establish a definitive pattern in the selective depression or eruption of teeth.

2. Demonstrable quantitative changes may be accomplished with a tooth positioner in a short period of time.

3. Root torque improvement of anterior teeth is possible, but apparent success in some cases is an illusion and a resultant of other movements.

4. The axial changes of anterior teeth are primarily due to tipping when using positioners.

5. The mandible may open in a hinge, or parallel manner, or not open at all when using a tooth positioner.

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Manuscript Preparation For Scientific Publication*

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Every orthodontist should strive toward a reasonable competence in scientific writing. Manuscript preparation is admittedly a difficult task for most. The author usually finds himself involved in an apparently endless process of sentence revision and rearrangement of the material in an attempt to present the text in concise, understandable and orderly fashion. It is unfortunate, for whatever the reason, that many of us are hard-pressed to put into words the things we are trying to say. It is obvious that the finished text cannot be any better than the experimental findings presented in the paper, but much of the value of excellent research can be lost to the reader if the manuscript is poorly written.

Each and every original paper presented formally before scientific groups is not necessarily of a caliber worthy of publication. In many instances, these papers represent a first effort, exclusive of the so-called term papers of college and dental school days. Personally, I can still recall that I was forced to discard my entire first year's research effort in graduate school and start over again. What I am saying in more or less oblique fashion is that considerable planning should enter into every research project before doing a single bit of the actual study. In the final analysis, manuscript preparation is only a matter of reasonable acquaintance with the Queen's English and assembly of the data into understandable form. A paper worthy of publication must have contributed to the general body of information in that particular area. The literary diarrhea characteristic of so many papers contributes nothing and even fails to stimulate controversy. From a more positive point of view, if a paper contains but one small step into the unknown, backed by hypothesis and supporting data, it is probably worthwhile.

There is no disgrace in seeking help in setting up experimental protocol before embarking on a project. Additional assistance in assembling the data and preparation of the manuscript will do much toward assuring a meaningful final result.

An orthodontist is judged by the quality of his work whether it be in his completed clinical cases or in the papers he has written for publication. In orthodontics, it has become popular to "measure something". Cephalometry has yielded itself nicely to this urge. As a consequence, all manner of angles and linear dimensions have been tabulated and attempts made to draw conclusions irrespective of whether they have a basis in fact. There is little value in squandering one's time in a series of cephalometric measurements which cannot be interpreted by the author or anyone else. I am afraid too many of us tackle a real or imaginary problem in Don Quixote style. One may be asked to write a paper for the Angle Society; in this there is infinite freedom as long as it has a relation to

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dentistry. Such a bright bold project might, for example, contemplate the investigation of root-end resorption. We can refer to this hypothetical investigation here in writing an equally hypothetical paper. It will be assumed that the data is reliable, of sufficient magnitude, and not shot full of uncontrolled variables. The task, then, is to present the idea, assemble the data, discuss the results, and finally draw, if possible, limited conclusions.

Let us consider the title: its selection may well be left until the manuscript is all but finished. In this case, however, let us assign the title at the beginning. It should give the reader an idea of what he is about to read. A smart title such as "You're at the End with Root-End Resorption" may get attention, but doesn't wear very well. In fact, it would look downright ridiculous. Alliteration is sometimes used: for example, "Root Resorption — Revelation or Retribution", or "Wrecked Roots — the Doctor's Dilemma". For the most part they are not very good. I can recall only one title in which alliteration was used cleverly and to good advantage. That was a paper written by a well-known orthodontist entitled, "Malocclusion — Malady or Malformation". I think this title stimulates one's curiosity and yet tells the reader in succinct fashion the subject of the paper. Perhaps the worst title I know is the one I used in my first graduate paper in bacteriology entitled, "The Immune Response to Parenteral Administration of Undenatured Streptococcal Bacterial Antigen". Had I but added a few words concerning experimental results, I would have had the entire paper right there in the title. I have always been astounded at Dr. Angle titling a paper "The Latest and Best . . . .". True, it was the latest, and it turned out to be the best, and perhaps he had reasons for this title not apparent to us. Nevertheless, once published, such a title is there in the literature to haunt the author as long as anyone cares to bring up the subject.

Specifically, the title should tell the reader as simply as possible what he is about to read. It should include all important nouns under which it can be indexed. The more important words should be at the beginning of the title for easy identification. A practical aid is to ask yourself, "Where would I look in an abstract journal index if I were searching for literature on the subjects treated in my paper?"

A good collegiate dictionary and Roget's *Thesaurus* are almost indispensable in writing a paper. Redundancy and misspelling are inexcusable. There are several texts concerned with writing for publication. I recommend one written by Trelease from which I have borrowed extensively in this paper. It is entitled *How to write Scientific and Technical Papers.*

The first section of the paper is generally concerned with a review of the literature. Search of the literature should have been done prior to final selection of the research problem. If one is unfamiliar with the subject to be undertaken, it is well to consult texts and monographs and *then* proceed with a review of the journals. It is increasingly important to be acquainted with the foreign literature as well as the American dental journals. It is amusing to examine bibliographies in some of the orthodontic literature; one will see extensive "padding", references which the author obviously threw in for good luck. One only fools himself in doing this. At the other extreme there is a textbook written by Sicher in which he has no bibliography or references at all. A thorough review of the literature is a *must* if one is to

do a good job in preparing his research paper. Reference to a few of the more pertinent findings of others in your paper will lend force and emphasis to the presentation of research findings.

It is no longer necessary to recount in each and every paper on the subject that Broadbent gave the profession the cephalometer in 1931, or that Brodie did a serial study of children from birth to eight years of age.

Perhaps the most difficult part of scientific writing is the organization and arrangement of subject matter.

1. The introductory sentence of a paragraph should tell the reader in more or less summary fashion what subject material is going to be developed within that paragraph. An orderly presentation of the topic is necessary if the reader is to follow the argument. Terms should be well defined and concise, logical support given each statement.
2. Clarity and definity will help the reader understand what is being said. Illustrations, photographs, charts and graphs can be used to good advantage. Ambiguity can be avoided if the rough draft is gone over carefully by someone who is well informed in the general area under discussion.
3. Word usage seems to be a stumbling block. If there is doubt, and a choice of words is possible in a given sentence, one should use the more common and more definitive word or term. No one is impressed by obscure, ambiguous or archaic language. For example, no one but an orthodontist would know what one means by the term "basal bone." Even the term, osteoid bone, is variously used and interpreted. I have often wondered who dreamed up the weasel term "dental unit". It must have been someone who was afraid to tell a parent that teeth had to be extracted. If it makes sense to call teeth dental units, then it must be equally correct to say, "Doctor, one of my dental units is aching".
4. Detailed consideration must be given to the logical presentation of ideas. New ideas should be supported by hypothesis. This offers a logical explanation for a given observed phenomenon based on the facts at hand. Trelease points out that it should:
   a. Be a guide toward additional investigation,
   b. Explain facts which have heretofore been unexplained,
   c. Be consistent with the experimental observations,
   d. Should be no more elaborate than absolutely necessary,
   e. Help predict new findings,
   f. Should be subject to verification or refutation.

It is unfortunate that many statements in the orthodontic literature have graduated from hypothesis to the level of general factual material simply by weight of the printed word and authority of the author. Some papers have no need of hypothesis. This would be true of one reporting the statistical compilation of the incidence of root-end resorption in the general population of orthodontically untreated, medically sound persons. On the other hand, there have been a multitude of ill-supported hypotheses purporting to show that root resorption is due to one thing or another.

One must be careful to avoid being drawn into illusions resulting from mechanical, arithmetical and statistical errors. There are those who seem to have a genius for avoiding common sense conclusions, but willing to trust

almost any statistical analysis, especially if it appears to be complicated. I recall a paper published by a graduate orthodontic student a few years ago on the etiology of root resorption in which the main thesis rested on statistical analysis. I like to think I employed common sense in recognizing my own inadequacies about statistics by consulting with an orthodontic colleague who has an excellent command of the subject. He was able to pinpoint the shortcomings of the statistical methods employed and thus laid open to question the author's conclusions which had bothered me only on a common sense basis. The lesson is that there is nothing wrong with statistics, per se, any more than there is, for example, with cephalometry. Both can be applied incorrectly and interpreted even more incorrectly. One should ask for help when necessary and not be afraid to expose his ignorance.

One should avoid broad generalizations. I think it must be our enthusiasm for a particular method of treatment, appliance gimmick or a new idea that prompts us to sell it at a table clinic or in a paper as being 99.44% true, give or take the other fractional percent.

In contemplating the meaning of a set of data, one can be lured into the trap of *cause and effect reasoning.* Just because one event follows another, one should not infer a cause and effect relation. The orthodontic literature is replete with this sort of thing. For example: mouth breathing *causes* narrow dental arches; thumb sucking *causes* Class II malocclusion; faulty sleeping habits *cause* crossbites; incorrect force application in orthodontic treatment *causes* root resorption, and many others. There may be elements of truth in all of these supposed cause and effect relationships, but not much more.

One must try to avoid scientific prejudice in writing although each and every one of us is subject to it. For example, we American orthodontists have a deep prejudice against certain European appliances while their proponents in turn feel sorry for us in using bands on teeth.

Finally, do not base conclusions on unproved propositions or hypotheses. When discussing or arguing a crucial point in the manuscript, try to stick to the question at hand. It is not too difficult to end up reasoning oneself into a position that proves one thing while it really proves something else. For example, I suspect many of us have had or tried to have an earnest discussion with our wives regarding the vicissitudes of the household budget only to have them prove that they really need a mink stole.

The presentation of data is, after all, the backbone of the paper. The inclusion of charts, figures and graphs help the reader only if they are uncluttered and well-arranged. All of these devices must be self-supporting. By that I mean one should be able to understand a chart without reference to the text. Therefore, the chart should have an explanatory title and, if necessary, a legend below. Headfilm tracings in particular have a way of getting cluttered up beyond recognition. Graphs with a half-dozen lines, some straight, some dotted, and some polkadotted are nearly impossible to interpret. Again, keep all figures and charts as simple as possible, eliminating extraneous material.

One is sometimes confused in planning a simple graph or chart in which there are two variables. The rule is that the independent variable is plotted on the abscissa or horizontal axis, while the dependent variable is plotted on the ordinate or vertical axis. For example, a chart expressing

root-end resorption in relation to time of treatment would have the degree of root resorption plotted on the vertical axis and the treatment time on the horizontal. However, if one were plotting treatment time against age, treatment time is the dependent variable and would be plotted on the vertical axis. The text is reserved for discussion and comparisons not obvious in the graphs or charts. One refers to a given chart in the text by pointing out significant findings therein and thereby avoids useless repetition. These findings can then be enlarged upon and generalizations made as indicated.

Let us now mention some of the difficulties encountered in ordinarv grammar and sentence construction:

1. Sentences should average about twenty words and preferably not exceed three typewritten lines or about forty words.
2. Simple sentences with normal order of subject, verb and object are preferable.
3. One should use compound sentences (those with conjunctions such as and, but) sparingly, converting them where possible into a sentence with a subordinate clause. This is a useful device to avoid reader confusion which may arise in relating the two halves of an ordinary compound sentence.

The matter of tense is sometimes perplexing. There are no strict rules, but the following general rules are helpful:

1. The experimental facts should be expressed in the past tense, e.g., root resorption was seen in half the cases. To express this finding in the present tense may well infer root-end resorption to be characteristic in fifty per cent of orthodontic cases.
2. The presentation of experimental findings should be in the present tense wherever possible, e.g., the the age distribution for root recorption is shown in Fig. 2.
3. Discussion of the results is generally in both the present and past tense, e.g., the greatest root resorption is shown in Case R.M., who was the oldest patient.
4. Specific conclusions and deductions should be expressed in the past tense. By doing this one emphasizes the special conditions of the experiment and avoids confusion with generally accepted truths. e.g., there was more marked resorption in all cases under treatment for two years.
5. General truths should be in the present tense. For example: a multibanded appliance affords more control in tooth movement than simple removable ones. In this example I have avoided the subject of root resorption because I don't know any general truths concerning the phenomenon.

I will not belabor you with rules of punctuation. But if I were to make a single suggestion, it would be this — when in doubt, use a period. Everyone is supposed to have learned correct usage of colons, semicolons, commas, parentheses and the like in grade school. Punctuation of coordinate or compound sentences, adverbial clauses and relative clauses should be second nature.

Capitalization of nouns is another source of confusion. I think some use a capitalized noun for things they hold in respect. For instance, neither edgewise appliance nor tip-back bends are capitalized in the middle of a sentence. A medicodental term involving the author's name need not be capitalized if that conforms with common usage. Examples might be: curve of spee, malphigian corpuscle. You will recall

that units of measurement such as ampere and watt and more recently, fermi, are not capitalized.

It is customary to use Arabic numbers for definite weights, percentages and degrees of temperature. On the other hand, it is preferable to spell out indefinite or approximate periods of time. For example, the patient was twelve years old. Never begin a sentence with a figure; either write the number in words or rearrange the sentence. However, figures are used for the day of the month, omitting the rd (as third), th (as eleventh), and st (as twenty-first).

In writing discussions, summaries and conclusions, Trelease wisely suggests watching for the following sources of difficulty:

1. Exaggeration of fact. (Be careful with the words "never" and "always".)
2. Omission of pertinent data
3. Errors in data and calculation
4. Conclusions based on faulty or insufficient evidence
5. Unreliable statistical treatment of data
6. Failure to distinguish between fact and opinion.

We often suffer from the inability to distinguish between fact and opinion. For example: it has been stated in high places that orthodontic expansion would stimulate the growth of bone; that it is impossible to move maxillary molars distally; that extraoral traction inhibits growth of the various sutures in relation to the maxilla; that the eruptive force of the third molar is responsible for mandibular incisor crowding; and many other like statements made in good faith but with insufficient evidence to brand them as general truths. Continued repetition of partial truths through the printed word seems to brand such statements as general truths until, fortunately, someone comes along and subjects them to closer scrutiny. One must watch for inconsistencies, particularly when generalizing on the experimental data. Don't prove black is black and later on prove it to be white.

We are most likely to publish articles in the *Angle Orthodontist* or in the *American Journal of Orthodontics*. Each of these journals gives the author rules for manuscript preparation. One usually has a particular journal in mind when he is preparing a manuscript for publication and the general format of published articles in that particular journal will be helpful in organizing the material. Above all, don't be afraid to ask for help in experiment planning; then later, seek editorial help. Finally, revise the manuscript until it says what you want it to say.

The Medical Center

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Instructions to Contributors

The author should submit the original typed copy of the manuscript, double-spaced on bond paper. The author's name and city of residence should appear immediately after the title, and the street address should appear at the end of the article.

Do not use symbols to indicate teeth; in *tables* teeth may be designated as U-1 or L-6, but in the text names of teeth should be fully written out.

Line drawings should be prepared in India ink on white stock; the width of lines and the size of lettering should take into account the fact that most illustrations are reduced in size in the engraving process. Photographs should be sharp, glossy prints of adequate size, *unmounted and kept separate from the text.* At the discretion of the editor, illustrations will be reproduced either as single column cuts of approximately 2¼ inches in width, or as double column cuts of 4¾ inches in width. The height of the cut may vary, but contributors should keep in mind that proportionate reduction or enlargement of illustrations affects all dimensions, and that arrangement of material should be such that awkward proportions are avoided and no loss of clarity results.

The Frankfort plane should appear in cephalometric tracings, and wherever possible should provide the basis of orientation of illustrative matter portraying the face, whether it be films, tracings or facial photographs. All material must be positioned with the facial profile on the right.

Extraneous details should be eliminated from illustrative matter in order to keep the salient portions of the cut as large as possible, i.e., the cranial outline should be eliminated from cephalometric tracings unless its ommission would be detrimental to the sense of the article, photographs of patients should be cropped closely, and photographs of models should be separated by a minimal amount of empty space. Illustrations will be returned to authors for revision when they do not comply with these specifications.

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